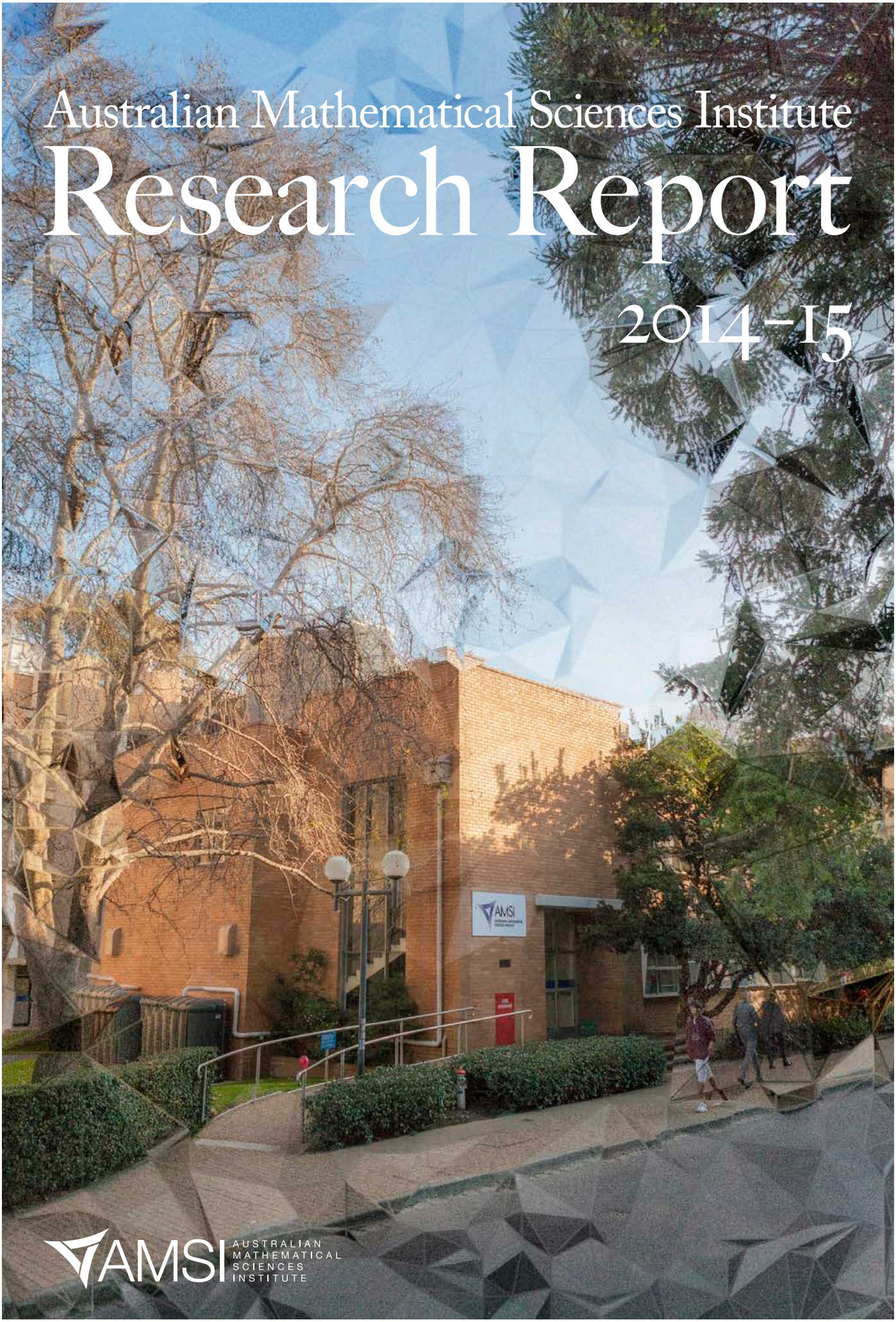
Australian Mathematical Sciences Institute

Research Report

2014–15



AMSI AUSTRALIAN MATHEMATICAL SCIENCES INSTITUTE

About AMSI

The Australian Mathematical Sciences Institute (AMSI) is a national collaborative venture of Australia's leading universities, professional societies and government agencies.

The central voice for the Australian mathematical sciences, AMSI is driving a strong policy and advocacy agenda to improve the effective and efficient delivery of mathematical and statistical capability to research, education and industry.

Our mission is the radical improvement of mathematical sciences capacity and capability in the Australian community.

AMSI delivers national programs to improve mathematical sciences outcomes within research, higher education, industry engagement and schools. We drive a range of activities including scientific workshops, distinguished visiting lectureships, short courses, professional development for school teachers and industry liaison.

AMSI Members

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University of Wollongong
Victoria University
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Government Agencies

Australian Bureau of Statistics
CSIRO
Bureau of Meteorology
The Defence Science and Technology Group

Societies

Australian and New Zealand Industrial and Applied Mathematics
Australian Mathematical Society
Australian Mathematics Trust

Peter Hall FRS FAA AO

LIKE SO MANY WITHIN THE AUSTRALIAN mathematical science community, staff and members of AMSI were saddened by the passing of Professor Peter Hall FRS, FAA, AO in January 2016.

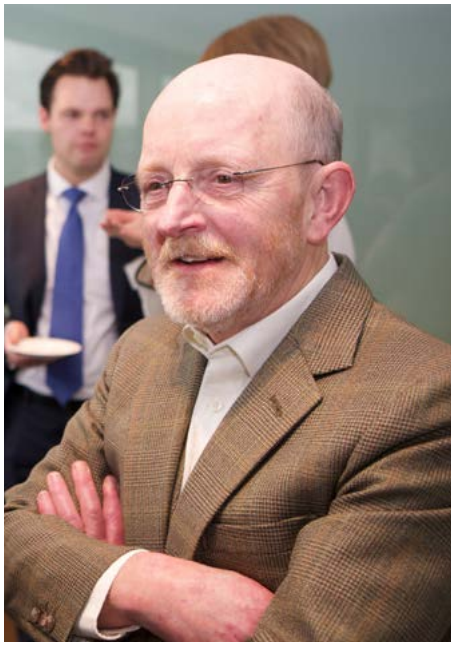
As one of the discipline's most iconic and respected leaders, Professor Hall will be remembered through his rich legacy of outstanding leadership and contribution to the Australian and global mathematical sciences.

The inaugural chair of AMSI's Scientific Advisory Committee, the workshop program flourished under his stewardship invigorating the Australian mathematical community. Featuring high profile international speakers, the events strengthened ties between the Australian and global mathematics communities.

Peter's leadership of this program contributed to a sense of national identity amongst Australian mathematical scientists, students and AMSI's member institutions.

In recognition of his contribution to the institute and mathematical sciences, Peter was one of the inaugural recipients of the AMSI Distinguished Service Medal in 2012.

Peter was universally respected and admired by all those he worked with and he will be remembered as a giant of the mathematical sciences who was as much a part of the fabric of Australian statistics as it was of him.



Creating the mathematical future

AMSI is Australia's national mathematical sciences institute. We have been driving research and research training since our formation in 2002. Annually we support around 20 workshops with significant international participation, residential schools, vacation research scholarships, lecture tours and major industry focussed symposia.

Collaboration is a key part of our DNA with all of our programs being delivered in conjunction with AMSI's 36 member institutions and learned societies around the country. Every research workshop, every summer and winter school and every lecture tour is designed for national impact.

This Research Report records the full range of the Institute's activities over the past year. It also marks a watershed for the mathematical sciences as we transition in 2016 to the new national research centre. Our aspiration is a radically expanded range of distributed programs encompassing extended themes, collaborative research groups, industry collaborations and a small grant scheme for individual workers.

Importantly, we will be scaling up our international engagement, especially with our sister institutes. Australia's physical attractions are well known and the mathematical environment is a stimulating one across the research spectrum. We warmly invite mathematical scientists and research students from around the globe to join our exciting new programs starting with MathsFest in Canberra in December 2016.

Professor Geoff Prince
Director

AMSI Milestones

2002

AMSI established. Prof.Garth Gaudry appointed Director (Victorian government $1m)

2003

Centre of Excellence for Mathematics & Statistics of Complex Systems (MASCOS) established (Australian government $10.9m)

2004

International Centre of Excellence for Education in Mathematics (ICE-EM) established (Australian government $7.8m)

2005

National Access Grid Network installed across Australia (Australian government $0.75m)

AMSI Awards100th Vacation Research Scholarship

1st edition of ICE-EM Mathematics textbooks published

2006

National Strategic Review of the Mathematical Sciences in Australia (Academy of Science)

2007

AMSI Higher Education flagship programs expanded (Australian government $2m)

2008

AMSI wins National Innovation Award for Science Innovation

Mathematics for 21st Century Engineering Students research project (ALTC $0.1m)

2009

AMSI Intern established

The Improving Mathematics in Schools (TIMES) project (Australian government $2m)

2010

AMSI sponsors 100th Scientific Workshop

AMSI Intern expanded (Australian government $1.7m)

2011

2nd edition of ICE-EM Mathematics textbooks published

2012

AMSI hosts 10th Annual AMSI Summer and Winter Schools

AMSI launches electronic resources to support new Australian school mathematics (Australian government $0.75m)

National Maths for the future forum: *keep Australia competitive*

Higher Education flagship programs expanded further (Australian government $2m)

2013

International Year of Mathematics of Planet Earth Australia led by AMSI

2014

AMSI Intern expanded (AMSI Member co-investment $6.7m)

AMSI places 100th intern

2015

Choose Maths launched to increase female participation (BHP Billiton Foundation $22m)

500th Vacation Research Scholarship awarded

10th Annual AMSI Lecture Tour held

About AMSI Research

AMSI Research has been supporting the advancement and communication of fundamental and applied knowledge in the mathematical sciences for over 13 years.

Building critical links between universities, government agencies and industry, our programs foster cross-disciplinary collaborations and industry experience to grow mathematical sciences capability and equip Australia as a STEM leader for the future.

Our research training schools, scholarships and graduate courses have enhanced learning outcomes for students and early career researchers and built student networks, creating the vibrant young community of researchers so important for innovation in the public and private sectors.

Research Committees

Reporting directly to the AMSI Board, the Scientific Advisory and Research & Higher Education committees are responsible for governance of all AMSI Research programs.

Research and Higher Education Committee (R&HE)

The R&HE Committee monitors mathematical sciences research across Australia and provides strategic advice to the AMSI Board and Executive.

Professor Gary Froyland, University of New South Wales (Chair)
Professor Geoff Prince, AMSI (Director)
Laureate Professor Jon Borwein, The University of Newcastle
Associate Professor Regina Burachik, University of South Australia
Michael Cromer, Australian National University
Professor Peter Caccetta, CSIRO
Professor Norm Dancer, The University of Sydney
Professor Andrew Eberhard, RMIT University
Professor Jan De Gier, The University of Melbourne
Professor Joseph Grotowski, The University of Queensland
Simi Henderson, AMSI
Associate Professor Inge Koch, AMSI
Professor Tim Marchant, AustMS
Dr Matt Ritchie, WEHI

Scientific Advisory Committee (SAC)

The SAC provides scientific advice for AMSI Research activities and reviews, as well as AMSI Scientific Workshops.

Laureate Professor Jon Borwein, The University of Newcastle (Chair)
Professor Geoff Prince, AMSI (Director)
Professor Ben Andrews, Australian National University
Professor Philip Broadbridge, La Trobe University
Professor Darren Crowdy, Imperial College London
Professor Ezra Getzler, Northwestern University
Associate Professor Frances Kuo, University of New South Wales
Professor Elizabeth Mansfield, University of Kent
Professor Kate Smith-Miles, Monash University
Professor Terry Speed, UC Berkeley; WEHI
Professor Terry Tao, UCLA; Clay Mathematics Institute
Professor Ole Warnaar, The University of Queensland

Disclaimer

Important

The following research workshop and event reports are not intended to be a comprehensive overview of research activities and events within the Australian mathematical sciences. These reports are developed in collaboration with event partners and may include views or recommendations from third parties that do not necessarily reflect the views of the Australian Mathematical Sciences Institute. Links to event websites and contact information provided are not intended as endorsements of views or information but are provided for the convenience of the reader.



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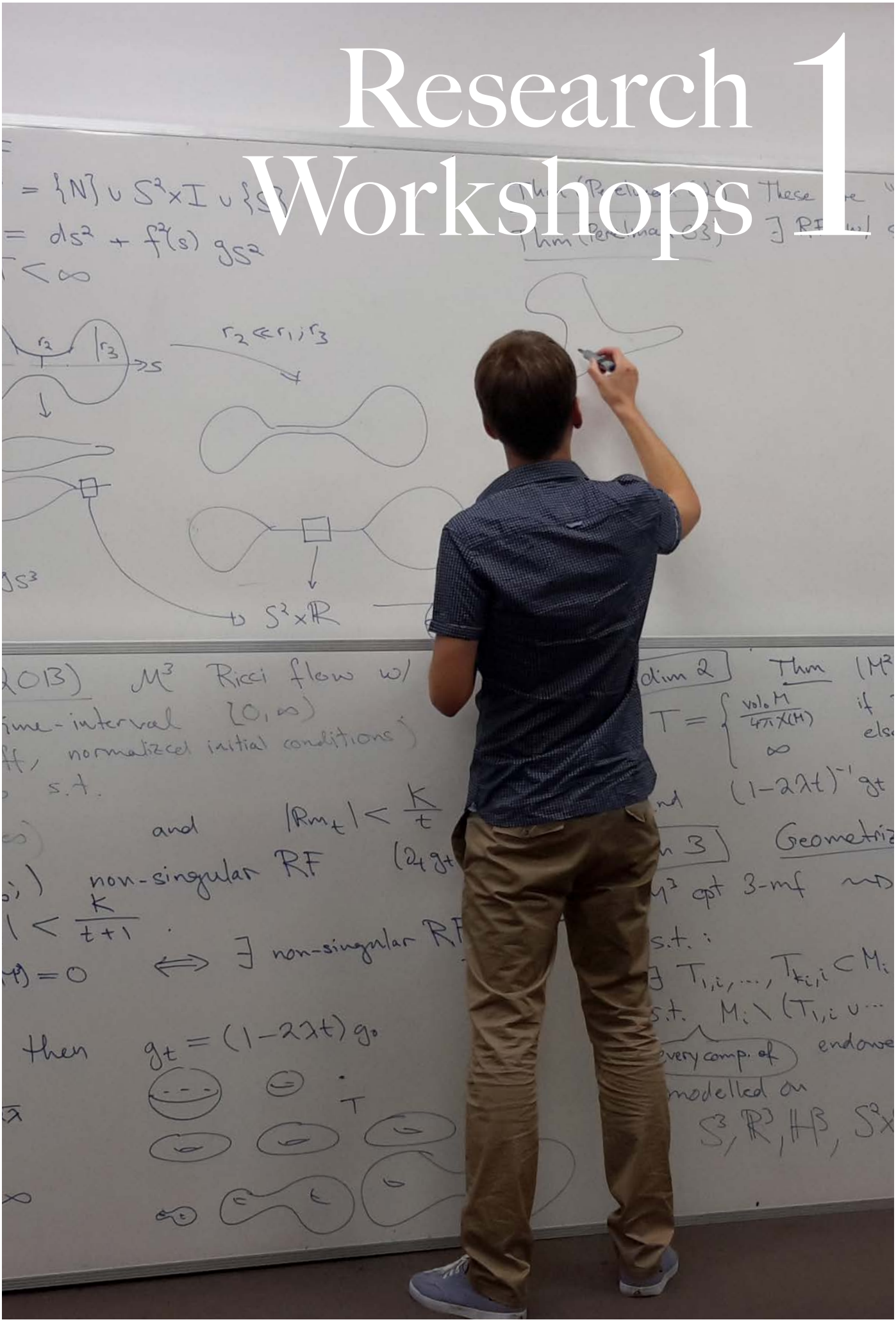

1.0 Research Workshops—Overview

Australia's premier sustained workshop program, AMSI Research builds mathematical research collaboration through our internationally recognised program of scientific workshops.

It has been a pleasure to chair the Scientific Advisory Committee since 2010 and to watch the strong growth of our activities. You will see from the number and variety of AMSI workshops and lecture series run during the year that mathematical sciences research being undertaken in our corner of the world is substantial and of high quality.

The funded events range from theoretical computer science and computation, through statistics and optimisation to number theory, geometric group theory and much more. And it is a pleasure to have welcomed so many international colleagues to our workshops in 2014–2015.

Thanks to the enthusiasm and energy of our membership, AMSI staff, and the members of the advisory committee—we are able to play a vital role in the STEM infrastructure of Australia.

Laureate Professor Jon Borwein, The University of Newcastle

Research Workshops

1.01 IMS-Finance, Probability and Statistics 2014 (IMS-FPS-2014)

University of Technology Sydney, 3–5 July 2014

This event was the fourth workshop of the *Finance, Probability and Statistics* (FPS) group under the auspices of the Institute for Mathematical Statistics (IMS, USA). A satellite of the joint Australian Statistical Conference/IMS Annual meeting, the workshop brought together leading academic experts, practitioners and junior researchers who have contributed to mathematical finance using probability and statistics.

During the High Frequency Trading pre-workshop Professors Philip Protter, Rene Carmona, and Xin Guo presented their research on new models for analysing trading strategies—an area of high interest within mathematical finance and applications research.

Other main topics of the workshop were: analytical and numerical methods for pricing financial contracts, retirement products and insurance, stochastic optimal control, risk management and regulation, stochastic analysis, energy markets, Monte Carlo methods and empirical properties of financial markets.

The workshop provided a great opportunity to mix with people from academia and industry.

The *Australian practitioners* session organised by National Australia Bank (NAB) Head of Market Research Quantitative Support, Dr Volf Frishling, featured a plenary talk by Dr John Jarratt, Head of Operational Risk Quantitative Analysis NAB on *Developments in operational risk modelling*. LIBOR market model (known as the BGM Model) co founder, Dr Alan Brace discussed some open problems in the area of interest rate modelling.

Selected papers from the event will be published in a special issue of the *ANZIAM Journal* devoted to recent advances in Financial Mathematics and Applied Stochastic Analysis.

A great success, attendees (students, academics and practitioners) benefited from the program's breadth of research and the quality of the international speakers. Questions and answer session following most talks generated opportunities for robust discussion.

"Meeting with other financial mathematicians was particularly useful. Apart from the excellent talks the conference was most enjoyable."

Workshop participant

Organisers

Professor Philip Protter, Columbia University
Professor Alex Novikov, University of Technology Sydney
Professor Xin Guo, University of California, Berkeley
Professor Steven Kou, Columbia University
Professor Kostya Borovkov, The University of Melbourne
Professor Ben Goldys, The University of Sydney
Associate Professor Juri Hinz, University of Technology Sydney
Professor Erik Shlogl, University of Technology Sydney
Adjunct Professor Pavel Shevchenko, University of Technology Sydney
Adjunct Professor Volf Frishling, University of Technology Sydney

Special presenters

Professor Rene Carmona, Princeton University
Research interests: probability, statistics, financial mathematics and commodity and energy markets
Professor Xunyu Zhou, University of Oxford
Research interests: quantitative finance, stochastic control, applied probability and mathematical behavioural finance
Professor Tze Lai, Stanford University
Research interests: clinical trial design and analysis, molecular therapeutics for cancer, population pharmacokinetics and pharmacodynamics, biostatistics, econometrics, quantitative finance and risk management, signal processing and engineering systems control, probability theory and statistical inference
Professor Dilip Madan, University of Maryland
Research interests: mathematical analysis, economic theory, statistical methodology and financial markets

MathSciNet Classification

91G80, 91G70, 91G80

Program structure

Running over four days, the workshop included 13 plenary and 45 invited talks. It was a great opportunity to mix with people from academia and industry.

Web Links

www.qfrc.uts.edu.au/IMS-FPS-2014/

Other Sponsors

IMS, AustMS

Contact

Timothy Ling, University of Technology Sydney
Timothy.Ling-1@uts.edu.au

Feature: The Fourth IMS-Finance, Probability and Statistics Workshop

Professor Kostya Borovkov, The University of Melbourne
Professor Alex Novikov, University of Technology Sydney (UTS)

THE FOURTH IMS-FINANCE, PROBABILITY & STATISTICS workshop highlighted statistical and probability contributions to mathematical finance and emerging areas.

Featuring a broad program, the workshop included: analytical and numerical methods for pricing financial contracts, retirement products and insurance, stochastic optimal control, risk management and regulation, stochastic analysis, energy markets, Monte Carlo methods and empirical properties of financial markets.

Professor Rene Carmona (Princeton University) led an exploration of *Equilibrium Analysis of Large Population Dynamics*, including the phenomenon of flocking as a dynamical system and its applications. As well as analysis of the market impact of flocking, percolation of information and systemic risk, this discussion covered probabilistic approaches to Mean Field Game and emerging relevant control problems.

Pioneered by Follmer, Sondermann and Schweizer, benchmarked risk minimisation leads beyond the classical no-arbitrage paradigm to provide a generalisation of pricing under classical risk minimisation in incomplete markets. Professor Eckhard Platen (UTS) discussed the problem of using the benchmark portfolio to hedge imperfectly replicable contingent claims. Benchmarked risk minimisation avoids restrictive assumptions that were standard in the previous work and provides symmetry with respect to all primary securities. It employs the real world probability measure and the benchmark portfolio to identify the minimal possible price for a contingent claim. In his presentation, Professor Platen claimed that the benchmarked risk minimisation is the least expensive method for pricing and hedging diversified pools of not fully replicable benchmarked contingent claims.

Other topics explored included rank dependent utility and risk taking (Professor Xunyu Zhou, University of Oxford), adaptive particle filters: theory and financial applications (Professor Tze Lai, Stanford University), a comparative study on time-efficient methods to price compound options in the Heston model (Carl Chiarella, UTS), developments in operational risk modelling (John Jarratt, National Australia Bank), modelling and monitoring risk acceptability in markets: the case of the credit swap (Professor Dilip Madan, University of Maryland), stochastic control problems with linear state dynamics (Associate Professor Juri Hinz, UTS), and sequential Monte Carlo and its applications in finance (Professor Rong Chen, Rutgers University). Attendees also viewed a pre-recorded plenary talk by Professor Albert Shiryaev on change-point detection problems on a finite interval.

Invited talks given at the event covered a wide range of topics, including high frequency trading. Professor Philip Protter (Columbia University) presented his paper *High Frequency Trading as Insider Trading: Why the NY State Attorney General might be right*. His work highlighted the dysfunctional role of high frequency trading in financial markets. In contrast to arbitrageurs who increase financial market efficiency by taking advantage of and eliminating mispricing, high frequency traders can create a mispricing and unknowingly exploit this to the disadvantage of ordinary investors. This mispricing is generated by the collective and independent actions of high frequency traders, coordinated via the observation of a common signal.

Exploring retirement products and insurance, a number of presented papers focused on the use mathematical methods and modern models to find optimal withdrawing strategy and model risks in the industry. There were also separate invited talks sessions on stochastic optimal control and risk management and regulation.

A highlight was *Australian Practitioners*, organised by Volf Frishling (National Australia Bank). This session attracted a lot of interest with BGM model for LIBOR market co-creator, Dr Alan Brace's talk on open problems in interest rate modelling.

There was also a special session devoted to the analysis of Japanese markets. A number of talks explored novel methods for solving the fundamental problems of mathematical finance: pricing financial options.

1.02 Geometric and Asymptotic Group Theory (GAGTA)

Newcastle, Australia, 21–25 July 2015

This meeting explored a wide range of areas within geometric and combinatorial group theory, spanning asymptotic and probabilistic methods, as well as algorithmic and computational topics involving groups. Areas of interest included group actions, isoperimetric functions, growth, asymptotic invariants, random walks, algebraic geometry over groups, the complexity of algorithmic problems, generic properties and complexity, and applications to non-commutative cryptography.

Featured presentations were the event opener by Professor Sarah Rees on recent advances in surveying sofic groups, and the closing address by Associate Professor Kate Juschenko exploring cutting-edge amenability research. The University of Newcastle Vice Chancellor and President, Professor Caroline McMillen's address during the conference banquet was also a highlight.

Professor Eamonn O'Brien gave an excellent talk illustrating links between his work on highly practical, computational (finite) group theory to infinite, geometric and asymptotic group theory.

With excellent schedule pace, high quality research presentations and opportunity for informal discussion, the event was a great success.

Organisers

Dr Murray Elder, The University of Newcastle
Dr Lawrence Reeves, The University of Melbourne
Dr Simon Smith, The University of Western Australia
Dr Anne Thomas, The University of Sydney

Special presenters

Associate Professor Yago Antolin Pichel, Vanderbilt University
Research interests: geometric group theory
Professor Oleg Bogopolski, University of Dusseldorf
Research interests: combinatorial and geometric group theory, algorithmic group theory, low-dimensional topology
Associate Professor Inna Bumagin, Carleton University
Research interests: geometric and combinatorial group theory
Swiss National Science Foundation Professor Laura Ciobanu, Université de Neuchâtel
Research interests: geometric group theory, formal languages in groups
Professor Volker Diekert, University Stuttgart
Research interests: word equations within algebraic systems, concurrent systems, traces theory, temporal logics and algebraic methods in computer science
Professor Susan Hermiller, University of Nebraska
Research interests: geometric and combinatorial group theory, asymptotic and homological properties
Associate Professor Kate Juschenko, Northwestern University
Research interests: geometric group theory, operator algebras, non-commutitive geometry
Professor John Meakin, University of Nebraska
Research interests: algebraic theory of semigroups, geometric group theory
Distinguished Professor Alexei Miasnikov, Stevens Institute of Technology
Research interests: combinatorial, geometric, algorithmic and asymptotic group theory
Associate Professor Masato Mimura, Tohoku University
Research interests: infinite discrete group theory, rigidity phenomena
Professor Eamonn O'Brien, University of Auckland
Research interests: finitely-presented groups and their quotients, isomorphism testing and computing automorphism groups of p-groups
Associate Professor Adam Piggott, Bucknell University
Research interests: combinatorial and geometric group theory, with a particular focus on the automorphism groups of groups, graph products of groups, and languages of normal forms for groups
Professor Sarah Rees, Newcastle University (UK)
Research interests: geometrical, combinatorial and computational group theory
Associate Professor Simon Smith, City University of New York
Research interests: group theory, combinatorics, permutation groups, graph theory, and topological groups
Associate Professor Enric Ventura, Universitat Politècnica de Catalunya · BarcelonaTech
Research interests: combinatorial, geometric, algorithmic, and asymptotic group theory
Professor Pascal Weil, University of Bordeaux
Research interests: theoretical computer science and algorithmic problems in algebra, combinatorial group theory

MathSciNet Classification

20F65, 20F69, 68Q01

Web Links

https://sites.google.com/site/gagta8/talks

Other Sponsors

The University of Newcastle: CARMA and Faculty of Science and Information Technology, The National Science Foundation (USA), AustMS

Contact

Dr Murray Elder, The University of Newcastle
murray.elder@newcastle.edu.au

1.03 The AMSI/ AustMS 2014 Workshop in Harmonic Analysis and its Applications

Macquarie University, 21–25 July 2014

The topics covered at this event included:

- Partial differential equations—Elliptic and parabolic systems, homogenisation of elliptic equations, heat kernel estimates, eigenfunctions expansion, Strichartz estimates on manifolds
- Harmonic Analysis—Estimates on singular integrals, holomorphic functional calculi, Carleson measures, harmonic analysis on product spaces
- Applied harmonic analysis—Image visualisation, prolate shifts & sampling

Presenting recent results at the frontier of each research topic, the talks were well attended and the workshop a great

"Excellent program of talks, the diverse range meant there was something for everyone."

Workshop participant

success. Michael Lacey's lecture on *the Two Weight Inequality for the Cauchy Transform* and its verification of a conjecture of Nazarov-Treil-Volberg was an event highlight.

The workshop attracted top-flight harmonic analysis researchers from the US, Europe, and Asia, with the format designed to facilitate networking between Australian and international researchers. This was particularly valuable for PhD students and ECRs.

Inspired by the discussions, a number of international speakers extended their time in Australia beyond the workshop in order to collaborate with Australian researchers.

Building on Australia's historical strength in this area, the event was effective in raising the overseas profile of Australian research. The event also proved an effective platform for the dissemination of recent results and encouraging discussion about future development, joint projects and collaborative opportunities.

Organisers

Professor Xuan Duong, Macquarie University
Dr Christopher Meaney, Macquarie University
Dr Lesley Ward, University of South Australia

Special presenters

Professor Leonardo Colzani, The Universita di Milano-Bicocca
Research interests: Fourier analysis in the settings of euclidean space and compact manifolds
Professor Michael Lacey, Georgia Institute of Technology
Research interests: harmonic analysis, longstanding A2 conjecture and the two-weight inequality for the Hilbert transform
Professor Carlos Perez, University of Seville, Spain
Research interests: singular integral operators and weighted inequalities
Professor Jill Pipher, Brown University
Research interests: harmonic analysis (including the multiparameter and dyadic theory) and elliptic partial differential equations

Program structure

The event featured an outstanding program of 24 morning and afternoon lecture sessions based around keynote presentations from special guest presenters. There was also plenty of social time, with a gathering on the Wednesday afternoon with proceedings officially coming to a close on Friday afternoon.

MathSciNet Classification

42B37, 42B20, 35J45

Web Links

https://rutherglen.science.mq.edu.au/~maths/ha2014/

Other Sponsors

AustMS, University of South Australia CIAM, Macquarie University

Contact

Associate Professor Lesley Ward, University of South Australia,
Lesley.Ward@unisa.edu.au

1.04 Number Theory Down Under

The University of Newcastle, 24–25 October 2014

Well represented by Kurt Mahler and Alf van der Poorten, number theory has been a core component of mathematical research in Australia and has undergone resurgence in recent years with many permanent appointments and research positions. To take advantage of this, number theory conferences (at the University of Newcastle and Macquarie University) have been arranged to bring together domestic and international number theorists to share ideas, and to pursue collaborative work.

The 2014 conference focused on the interaction between Diophantine approximation, transcendence theory and analytical computations.

The role of computation in the approximation and transcendence theory has expanded greatly in recent years. Not only can powerful machines evaluate numerical constants to high precision, but numerical searches of finite cases can establish theorems. This has spurred tremendous advances in the calculation of special values of special functions (for example, multiple zeta-values) and on the measure of how 'irrational' certain numbers are.

This year's event organisers were particularly delighted by the high presence of students (undergraduate and graduate) in the program.

Feedback from participants indicated that this conference should become a yearly fixture. Participants agreed that Harbourview Function Centre would make an ideal setting for future meetings.

Organisers

Dr Mumtaz Hussain, The University of Newcastle
Dr Timothy Trudgian, Australian National University

Special presenters

Laureate Professor Jon Borwein, The University of Newcastle
Research interests: computer assisted mathematical research, high performance computing, applied mathematics, functional and numerical analysis, data mining, discrete mathematics, dymatical systems, machine learning
Professor Wadim Zudilin, The University of Newcastle
Research interests: number theory and its applications
Professor Richard Brent, FAA, Australian National University & The University of Newcastle
Research interests: computational number theory and analysis of algorithms
Professor Igor Shparlinski, FAA, University of New South Wales
Research interests: exponential and character sums, and their applications to cryptography
Associate Professor Simon Kristensen, Aarhus University
Research interests: analytical number theory, especially metric diophantine approximation
Dr Dzmitry Badziahin, Durham University
Research interests: metric diophantine approximation
Dr Yohei Tachiya, Hirosaki University
Research interests: multiple zeta values

MathSciNet Classification

11J13, 11K60, 11M26

Web Links

https://carma.newcastle.edu.au/meetings/ntdu2/

Other Sponsors

CARMA

Contact

Dr Mumtaz Hussain, The University of Newcastle
Mumtaz.Hussain@newcastle.edu.au

1.05 Conference on Geometric Analysis and Stochastic Methods in Geometry

The University of Queensland, 21–25 July 2014

Bringing together prominent international and Australian geometric analysis experts, this conference highlighted the application of probabilistic methods in differential geometry problems and partial differential equations. Much of the discussion focussed on the high profile areas of heat kernels, Ricci curvature equations and the Willmore functional.

A modern and vibrant area of mathematics, geometric analysis has been broadly applied to achieve remarkable results, many of which were explored by conference participants using traditional and probabilistic techniques. In particular, Professors Elton Hsu, Anton Thalmaier, and Bruce Driver contributed presentations tailor-made as "User Guides" to probabilistic methods in geometric analysis, detailing for example the connection between Hamilton's classical gradient estimate and Brownian motion. This alternative point of view enables the observation that Hamilton's gradient estimate is the limiting case of an entire family of gradient estimates.

The conference enjoyed contributions from established experts in the area as well as new stars. Professor Rick Schoen opened the conference with a fundamental new contribution on the application of localisation in cones to the analysis of the rigidity of asymptotically flat space-times. A vast survey was contributed by Professor Karl-Theodor Sturm, Hausdorff Centre and Professor Gerard Besson, Fourier Institute, presented startling facts on how weird and wonderful 3-manifolds may be.

Leading Australian mathematicians were well represented, with a deep application of interior ball curvature presented by Professor Ben Andrews (Australian National University) and Laureate Professor Xu-Jia Wang (Australian National University) detailing recent developments on the p-Minkowski problem.

Distinguished presentations from young mathematicians included that of Dr Yann Bernard (ETH Zurich), speaking on energy quantisation for the Willmore functional, work that recently appeared in the *Annals of Mathematics*, and Dr Richard Bamler (University California, Berkeley) who found new insights in Perelman's work on the Ricci flow, enabling him to drastically improve on previous results. Given the level of activity in Ricci flow and in particular the level of interest in Perelman's work, this is an astonishing achievement.

This conference provided many benefits to the Australian scientific community.

Organisers

Professor Thierry Coulhon, Australian National University
Dr Huy The Nguyen, The University of Queensland
Dr Artem Pulemotov, The University of Queensland
Dr Glen Wheeler, University of Wollongong
Dr Valentina-Mira Wheeler, University of Wollongong

Special presenters

Distinguished Professor Rick Schoen, University California, Irvine
Research interests: geometric analysis, general relativity, compact manifolds
Professor Bruce Driver, University California, San Diego
Research interests: probability theory, the analysis of partial differential equations, mathematical physics, geometric group theory and stochastic analysis

MathSciNet Classification

35J60, 30C40, 60D05

Web Links

https://www.smp.uq.edu.au/GASMG-2014

Other Sponsors

Australian National University, The University of Queensland, University of Wollongong, AustMS

Contact

Dr Artem Pulemotov, a.pulemotov@uq.edu.au

Feature: Geometric Analysis and Stochastic Methods in Geometry

Dr Artem Pulemotov, The University of Queensland
Dr Glen Wheeler, University of Wollongong

THE RANGE OF TOPICS DISCUSSED AT THE CONFERENCE WAS extensive. Two of the primary unifying themes for these topics were the heat kernel and the Ricci curvature. A large portion of the talks focused on geometric flows, i.e. partial differential equations describing time-evolutions of geometric objects, such as Riemannian metrics or connections in a vector bundle. One prominent example is the Ricci flow

$$\frac{\partial}{\partial t} g(t) = -2\,\mathrm{Ricci}(g(t)).$$

The unknown in this equation is the Riemannian metric $g(t)$ depending on the time parameter t. Intuitively, the Ricci flow "uniformises" or "improves" the initial data $g(0)$ as t tends to infinity. It's best known for its key role in the proof of the Poincaré conjecture. However, it has numerous other applications in geometry, topology, mathematical physics and other fields. For more information, we refer to the many excellent books on the subject, such as [8, 19, 16].

Lectures by Richard Bamler and Qi Zhang delivered at the conference focused on the Ricci flow and its complex analogue, the Kähler-Ricci flow. Joseph Grotowski and James McCoy presented results obtained through symmetry reductions for several other geometric evolution equations. Simon Blatt and Yoshihiro Tonegawa reported on the use of such equations in the study of knots and networks. In Xu-Jia Wang's lecture on the p–Minkowski problem, a geometric flow was used to prove the existence of solutions. Yann Bernard presented an energy quantisation theorem for the Willmore functional

$$W[f] = \frac{1}{4}\int_{\Sigma} H^2\, d\mu.$$

Here, $f\colon \Sigma \to \mathbb{R}^n$ denotes an isometric immersion, Σ is a closed 2-manifold, $H = \Delta f$ is the mean curvature vector, and $d\mu$ is the area

measure. Originally introduced hundreds of years ago and studied particularly intensively since the 1960s, the Willmore functional is closely related to the energy functional for the biharmonic map heat flow. It has enjoyed increased attention in the last few years due to the recent progress on the Willmore conjecture proposed in [20] and proven in [15].

The theory of geometric flows has close ties with general relativity; see, for instance, [10, 11]. Both fields are continually enriched through transfer of techniques and observations from one to another. These ties were explored at the conference, primarily through the lectures of Richard Schoen and Todd Oliynyk. The Einstein equation of general relativity is

$$\mathrm{Ricci}(g) - \frac{1}{2} R(g)\, g + \Lambda g = \frac{8\pi G}{c^4}\, T. \qquad (1.1)$$

The unknown in it is a Lorentzian metric g. The notation $R(g)$ stands for the scalar curvature of g, Λ is the cosmological constant, G is Newton's gravitational constant, c is the speed of light, and T is the stress-energy tensor. Richard Schoen spoke about asymptotically flat solutions to equation (1.1) and presented a result regarding the size of the flat regions contained in nontrivial solutions. Todd Oliynyk discussed Newtonian gravity as an approximation for general relativity on a cosmological scale.

One of the key themes of the conference was the use of probabilistic techniques in the analysis of geometric partial differential equations. Such techniques exploit the theory of stochastic integration and often rely on the Itô formula. As we explain below, they yield several gradient estimates for solutions to heat-type equations. They have also been applied in Yang-Mills theory and the study of harmonic maps; see, e.g., [18, 5, 1]. It is worth noting that developing stochastic integration on manifolds and generalising the Itô formula accordingly is in itself a difficult task. We refer to the book [12] for an introduction to the subject.

The study of gradient estimates for solutions to heat-type equations is an area of highly intensive research with numerous applications throughout mathematics. One of the most classical such estimates was proven in [9] and states that

$$\frac{|\nabla u|}{u} \leq \sqrt{\frac{1}{4} \log \frac{A}{u}}. \qquad (1.2)$$

Here, u is a positive solution to the heat equation on a closed Riemannian manifold with nonnegative Ricci curvature, $t > 0$ is the time variable, and A is a positive constant. Several versions of (1.2) appeared since the paper [9] was published; see, for instance, [17, 6, 3]. If one wishes to incorporate the t-derivative of u into the estimate, one finds

$$\frac{|\nabla u|^2}{u^2} - \frac{u_t}{u} \leq \frac{n}{2t} \qquad (1.3)$$

where n is the dimension of the manifold. Formula (1.3) originated from the papers [2, 14], it is customarily called the Li-Yau inequality or the differential Harnack inequality. Many variants of (1.3) now exist in the literature; see, e.g., [13, 7, 4]. The analogue of this estimate for the Ricci flow has become one of the central tools in classifying ancient solutions to the flow, as detailed in [8, Chapter 9]. Note that integrating (1.3) along a space-time curve yields the Harnack inequality.

In his presentation Elton Hsu explained an approach to gradient estimates that relies on stochastic techniques. Among its other advantages, this approach provides a new way to extend such estimates from closed manifolds to manifolds with boundary. This is achieved by replacing Brownian motion involved in the argument by reflecting Brownian motion.

One of the significant problems in the theory of gradient estimates is extending them to heat-type equations coupled with geometric flows (e.g., the Ricci flow). This problem is well-suited for a probabilistic interpretation and treatment. This subject formed the bases of Anton Thalmaier's lecture, during which he described a stochastic process associated with the heat equation on a Riemannian manifold evolving by the Ricci flow. Li-Yau-type estimates were also considered, with Karl-Theodor Sturm using his talk to discuss them in the context of metric-measure spaces. Bruce Driver spoke about the heat equation on the Lie group $U(N)$ for large N. Explaining, among other things, several intriguing properties that the Laplacian possesses in this setting.

The range of topics covered at the conference was further broadened by Jaigyoung Choe's presentation on new characterisations of the catenoid and helicoid, and a trip down the rabbit hole of open 3-manifolds with Gerard Besson. Ben Andrews also presented on a nonlocal curvature quantity, called the interior ball curvature, that satisfies interesting differential inequalities. He showed how this notion lead to non-collapsing results and proofs of the Lawson and Pinkall-Sterling conjectures for CMC surfaces in spheres.

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1.06 Robust Statistics and Extremes

Australian National University, 8–11 September 2014

The Robust Statistics and Extremes Conference brought the related but not usually connected themes of robustness and extremes together with functional data analysis in a stimulating and enjoyable event. Australia has a significant presence on the world stage in the important and highly topical areas of robust statistics and extreme value theory, and their applications. There have been enormous advances in recent years in the application of these methods in particular to the analysis of extremely large data sets and high dimensional data such as is found in genetics, finance, physics, astronomy, and many other areas.

The conference featured a series of presentations, seminars and practical discussions exploring the cutting-edge of robust statistics, extreme value theory and its applications, and high dimensional and function data analysis.

The robust statistics sessions showcased the very latest developments in the field. A panel of experts presented research on high-dimensional data analysis, robust filtering, outlier detection for functional data and robust component analysis, generalised likelihood ratio tests for heterogeneous sparse normal mixtures, and one-sided Winsorization sample surveys. Presenters included Peter Hall (The University of Melbourne), Elvezio Ronchetti (University of Geneva), Matias Salibian-Barrera (University of British Columbia), Jingling Wu (University of Calgary), Janice Scealy (Australian National University), Thomas Porter (The University of Sydney) and Robert Clark (University of Wollongong).

With a focus on practical discussion, the extreme value sessions touched on the ever-topical and critical issue of climate change, as well as other modelling applications and theoretical presentations. Presenters included Ana Ferreira (ISAUL and CEAUL, Portugal), Debbie Dupuis (HEC Montreal), Yuguang Fan (Australian National University), Daniel Gibbons (The University of Queensland), Yang Liu (CSIRO), Wangyue Xie (The University of Queensland) and Peter Cayton (Australian National University).

High Dimensional and Functional Data Analysis is currently a very hot topic of research related to interests in "Big Data" and "Machine Learning". Seminars included those by Aurore Delaigle (The University of Melbourne): Classification Using Censored Functional Data, HanLin Shang (Australian National University): A Bayesian method for determining the optimal semi-metric and bandwidth in scalar-on-function quantile regression with unknown error density and dependent functional data, Robert Staudte (LaTrobe University): Inference for Ratios of Finite Linear Combinations of Quantiles, and Garth Tarr (Australian National University): A pairwise approach to estimating precision and covariance matrices under cell-wise contamination.

On the final morning a Swiss Tea was a highlight. It was held to mark the 50th anniversary of the publication of P.J.Huber's 1964 paper, *Robust estimation of a location parameter*. This paper played a major role in the development of robustness theory, as it introduced M-estimators, established their asymptotic normality (including in non-smooth cases), proposed and implemented a minimax treatment of the robust estimation, derived the least favourable distribution for the core Gaussian location problem and the associated Huber M-estimator, showed the optimality of the median for asymmetric contamination, proposed three methods of simultaneously estimating scale (including the famous Huber proposal II method), and more.

The conference was very well received, bringing together prominent Australian and international experts to provide researchers and students with the opportunity to hear up-to-date, state-of-the-art expositions. There was a substantial audience of local and international researchers and postgraduate students in attendance. The conference also attracted significant interest from government and industry.

Organisers

Professor Ross Maller, Australian National University
Dr Boris Buchmann, Australian National University
Yuguang Fan, Australian National University
Dr Bronwyn Loong, Australian National University
Professor Steven Roberts, Australian National University
Dr Dale Roberts, Australian National University
Professor Alan Welsh, Australian National University
Tiandong Wang, Australian National University
Professor Ana Ferreira, University of Lisbon

Special presenters

Professor Aurore Delaigle, The University of Melbourne
Research interests: functional data classification
Professor Debbie Dupuis, University of Montreal
Research interests: robustness and extreme values, with applications in areas ranging from temperature modelling to futures derivatives and actuarial studies
Professor Manuel Febrero-Bande, University De Santiago de Compostela
Research interests: aspects of generalised additive models, with special reference to functional models and data, empirical processes, influence and outliers, etc. Applications are to times series, ozone data, financial data, etc
Professor Ana Ferreira, University of Lisbon
Research interests: extreme value methods theory and its application
Professor Peter Hall, The University of Melbourne
Research interests: nonparametrics and semiparametrics, and applications in economics and in the physical, engineering and biological sciences
Dr Luke Prendergast, La Trobe University
Research interests: robust statistics, dimension reduction and visualisation of high dimensional data, meta analysis (in particular meta regression) and statistical analysis for weight loss studies
Professor Elvezio Ronchetti, University of Geneva
Research interests: theory of robust statistics and the application of robust procedures to statistics, econometrics, and finance, asymptotic expansions, saddlepoint techniques, exploratory data analysis and statistical computing
Professor Matias Salibian-Barrera, University of British Columbia
Research interests: robustness and bootstrapping

MathSciNet Classification

62G32, 60G70, 60K10

Web Links

http://maths.anu.edu.au/events/robust-statistics-and-extremes

Other Sponsors

Mathematical Sciences Institute "Special Year", the Australian National University Research School of Finance and Actuarial Studies and Statistics, the Australian National University

Contact

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1.07 New Directions in Fractal Geometry

Australian National University & its Coastal Campus at Kioloa, 23–28 November 2014

Fractal geometry is a fast growing and dynamic area of mathematics. This meeting succeeded in stimulating research and collaboration between theory and application with a focus on key areas within fractal geometry including, antenna design, materials design, image analysis and fractal scanners.

Presentations from leading international figures Valerie Berthe, Doug Hardin, Jun Kigami and Konstantin Igudesmann explained research on links between fractals and Kronecker dynamics, discrete minimum energy problems, self-similar sets as quotients of shifts and applications to fractal antennas.

Jörg Thuswaldner spoke on the topology of self-affine tiles, Jeff Geronimo on a separation condition for fractal attractors, Irmina Herburt on fractal star bodies and Mike Whittaker on fractal substitution tilings.

The program provided a platform for discussions between early career researchers and established experts, as well as people from different specialisations and those working in theory and application.

Key talks were given by Michel Lapidus on links between fractals and non-commutative geometry, Károly Simon on multi-fractal analysis of traffic on the internet, Christoph Bandt on fractal morphisms, Jon Borwein on short walks, Markus Hegland on connections between numerics and fractals, Christian Gentil on applications of fractals in computer aided design and Andrei Tetenov on self-similar Jordan arcs.

There was a strong groundswell that this conference should be the starting point of a series.

"The conference talks were rich in new ideas, transforming the very foundations of fractal geometry."

Professor Andrei Tetenov, Gorno-Altaisk University

Organisers

Professor Michael Barnsley, Australian National University
Professor Chistoph Bandt, University of Greifswald
Laureate Professor Jon Borwein, The University of Newcastle
Professor Markus Hegland, Australian National University
Professor Ka-Sing Lau, Chinese University of Hong Kong

Special presenters

Professor Valerie Berthe, CNRS-University Paris Diderot
Research interests: symbolic dynamics, ergodic theory, Diophantine analysis, combinatorics on words and discrete geometry
Professor Michel Lapidus, University of California
Research interests: spectral and fractal geometry, a higher-dimensional theory of complex fractal dimensions, fractal geometry, dynamical systems, and their applications
Professor Jun Kigami, Kyoto University
Research interests: mathematical foundation of fractals, in particular, analysis of fractals
Professor Jörg Thuswaldner, University of Leoben
Research interests: elementary and analytic number theory, fractal geometry and topology

MathSciNet Classification

60G18, 37N35, 28A80

Web Links

http://maths.anu.edu.au/people/louisa-barnsley
http://maths.anu.edu.au/events/new-directions-fractal-geometry/

Program Structure

The symposium began with a full day of research talks. This was followed by four half days with afternoons to free to encourage attendees to interact amongst themselves.

Public Lecture

In the evening Professor Michel Lapidus (UCal) gave a public lecture titled *An Invitation to Fractal Geometry and its Applications* to an appreciative audience.

Other Sponsors

AustMS, CARMA, Australian National University, Fractal Antenna Inc. and ACEMS

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1.08 Effective Visualisation in the Mathematical Sciences (EViMS 2)

Australian National University, 21–23 November 2014

The workshop took place over an extremely hot Canberra weekend, despite the heat all sessions from start to finish were well attended by the participants and there were many fascinating presentations.

This workshop was a sequel to EViMS held at the University of Newcastle in 2012. EViMS events will provide an ongoing forum for mathematical researchers and educators with an interest in visualisation.

The meeting brought together experts from universities, schools and the private sector to pool their knowledge of visualisation tools and how they can support mathematics teaching, enhance experimental mathematics and aid in the providing of theorems.

Seeing the practical results some speakers had achieved with computer-based tools was a highlight. For example, Anthony Morphett (Melbourne) and Krzysztof Les´niak (Nicolaus Copernicus) both presented GeoGebra applets for teaching undergraduates, Andrei Tetenov presented results from IFSBuilder 3D and Elias Wegert showed what his Matlab based, *Complex Function Explorer* could achieve.

Organisers

Professor Michael Barnsley, Australian National University
Laureate Professor Jon Borwein, The University of Newcastle
Dr Judy-anne Osborn, The University of Newcastle
Louisa Barnsley, Australian National University
Dr Gerard Joseph, IBM

Special presenters

Professor Elias Wegert, TU Bergakemie Freiberg
Research interests: geometric function theory, boundary value problems for holomorphic functions (Riemann-Hilbert problems, Beurling's problem), singular integral equations (including numerical methods and applications), circle packing, visualisation of complex functions, games on graphs
Professor Andrei Tetenov, Gorno-Altaisk University
Research interests: fractal geometry, topology, complex analysis, hyperbolic geometry, mathematical visualisation, building striking counterexamples, new methods of teaching mathematics
Professor Peter Eades, The University of Sydney
Research interests: the mathematics and algorithmics of geometric graphs
Professor Christoph Bandt, University of Greisfwald
Research interests: fractal geometry time series analysis and various interdisciplinary projects with physicists, biologists and physicians

MathSciNet Classification

00A35, 97C99, 76M27

Web Links

http://maths.anu.edu.au/events/effective-use-visualisation-mathematical-sciences-evims-2
http://maths.anu.edu.au/people/louisa-barnsley

Other Sponsors

AustMS, CARMA, Australian National University and ACEMS

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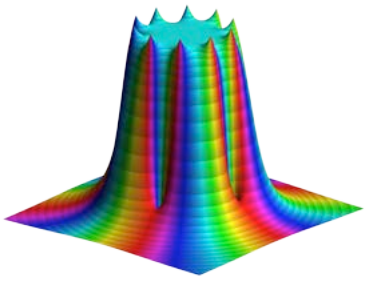
Feature: New Visualisation Methods



Louisa Barnsley, Australian National University

NEW VISUALISATION METHODS, BOTH software and hardware are appearing on an almost daily basis. How best can the mathematical sciences use these new opportunities to assist education and research? The coming generation of students has great familiarity with visual content; how can visual content be created and used to improve education as well as teaching analytical thinking? What computer-based methods of teaching are actually effective rather than yielding illusory outcomes? The aim of EViMS 2 was to address these questions by bringing together experts from universities, schools and the private sector.

Speakers reported on how visualisation methods were being developed and evaluated. The topics covered fell into two main areas: visualisation as an aid in mathematical research, and visualisation as a tool in the teaching of mathematics and outreach to the public.

Peter Eades (The University of Sydney) analysed what makes a good diagram. In this talk the data was assumed to be a very large graph, with the 'visualisation' of this graph created by a computer program. He rigorously defined the concepts of a diagram, the visualisation function, the perception function perceived by a human who is trying to gain knowledge, quality metrics, faithfulness to the underlying data and readability. He described some of the history of visualisation quality metrics and in particular the state-of-the-art in *edge crossing* and *stress* quality metrics. He concluded we need better quality metrics for graph visualisation and better faithfulness metrics for large graph visualisation. He suggested the *Jaccard sum similarity* was a good candidate for a metric but noted it is hard to optimise. There is plenty of work left in this area that will become more important with the increasing size and complexity of the data sets.

Elias Wegert (TU Bergakemie Freiberg) spoke about exploring complex functions using phase plots. The graph G of a function f in the complex plane is a surface in a four-dimensional space. The traditional method to help in its visualisation is an 'analytic landscape' diagram; but this only shows the absolute value of the function with the very important argument (phase) of the function merely being indicated by lines of constant phase. A better way to visualise the function is to use $f(z)/|f(z)|$ which lives on the unit circle and can be conveniently encoded by a circular colour scheme that can be viewed from 'on top' to see the phase portrait of the function. The colour schemes can be varied to 'see' many important characteristics of the function by inspection of the phase portrait. Elias illustrated his talk with many wonderful phase portraits created with his software *Complex Function Explorer*, words can not

do justice to the amazing, informative and colourful images included in Elias's talk. For more information visit his website at www.visual.wegert.com/.

Andrei Tetenov (Gorno-Altaisk University) showed 3D iterated function system (IFS) attractors produced with *IFSBuilder 3D*. This software can be downloaded from http://fractals.nsu.ru/builder3d_en.htm. The 3D attractors can be viewed from any angle and the lighting and shadows adjusted for best effect. Various families of functions are available in the system including affine and Möbius functions.

Christoph Bandt (University of Greifswald) spoke about visualising 'big data'. Data would be a series of measurements from a sensor, say $x_1,x_2,\ldots,x_T$; where T is very large say $10^4 < T <= 10^7$. Viewing the graph of such a large set of data is often not helpful, we need more effective ways to visualise the data. Christoph explained a number of methods. The *up-down balance method* measures whether the data goes 'more upwards' or 'more downwards' over *d* steps. This function represents the dependence structure of the underlying process, say atmospheric temperature values, and its values can be graphed to provide insights. Another method is to find the *relative frequency of order patterns* of some particular length within the data. A *sliding windows analysis* breaks the time series into disjoint or overlapping pieces, so-called windows, with a time index *w* and then correlation functions are determined for each window. These functions can then be displayed with the values colour coded, like height in a geographical map. His conclusion is that big data time series often have a multi-scale structure and that the best way to get an understanding of the underlying mechanisms is to start by getting an overview by appropriate visualisation. Due to the decreasing price of sensors, the quantity of data being collected is growing fast. Examples are individual body sensor data for individualised medicine or measurements of particulates in the atmosphere. To quote Christoph: "Big data is crying out for mathematics. It is creating new opportunities for mathematics. As researchers we need to accept this challenge, as teachers we need to inform our students!"

Anthony Morphett (The University of Melbourne) and Krzysztof Leśniak (Nicolaus Copernicus) presented *GeoGebra* applets for teaching undergraduates. An applet differs from a program in that it 'just works' in the browser, uses familiar syntax and is easily distributed whereas a traditional program requires downloading, installing and learning. Applets are a very useful and effective teaching aid for undergraduate mathematics because they provide a visual representation of difficult concepts, they can be tailored to a particular teaching context, they are transferable across learning and teaching domains, they are flexible, accessible, interactive and fun! The University of Melbourne applets are here www.melbapplets.ms.unimelb.edu.au/.

The heart of the conference was the talk by Lilia Ferrario (Australian National University). She gave an overview of learning state-of-the-art showing there are three types of mathematical minds: an analytic type, a geometric type and a harmonic type, and two components of thinking processes: verbal-logical that enables people to work with abstract problems, and visual-pictorial which requires visualisation. The most effective teaching will include elements that present the material in ways that can be accessed efficiently by all the different types of minds. The same ideas also apply in research, especially when the research involves very large amounts of data. Lilia reported on how utilising visualisation as well as traditional mathematical teaching methods can help students in learning important concepts in calculus.

Jonathan Borwein (The University of Newcastle) spoke on the importance of "experimental mathematics": that is the use of computers to run computations, look for patterns, identify particular numbers and sequences and to gather evidence in support of specific mathematical assertions. He also recounted how a visualisation of the first 100 billion digits of π went viral, providing terrific outreach to the general public.

Other excellent talks were given by Judy-anne Osborn (The University of Newcastle) on visualisation as a bridge between research, outreach and teaching. Paul Leopardi (The University of Newcastle) on using visualisation to access crowd funding for mathematics. Attila Egri-Nagy (Western Sydney University) on the "big data era" of semigroup theory. Brendan Harding (Australian National University) and Emma Ai (Australian National University) on using visualisations of 3D fractal transformations to gain insight into fractal geometry and Kurt Pudniks on visualising the Reynolds flocking boids algorithm.

Figure 1 - Some EViMS2 attendees keeping cool

Figure 2 - example of a phase portrait

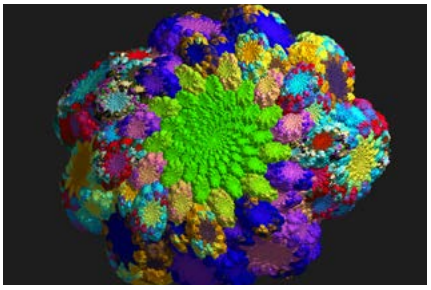


Figure 3 - Affine IFS output from IFSBuilder 3D

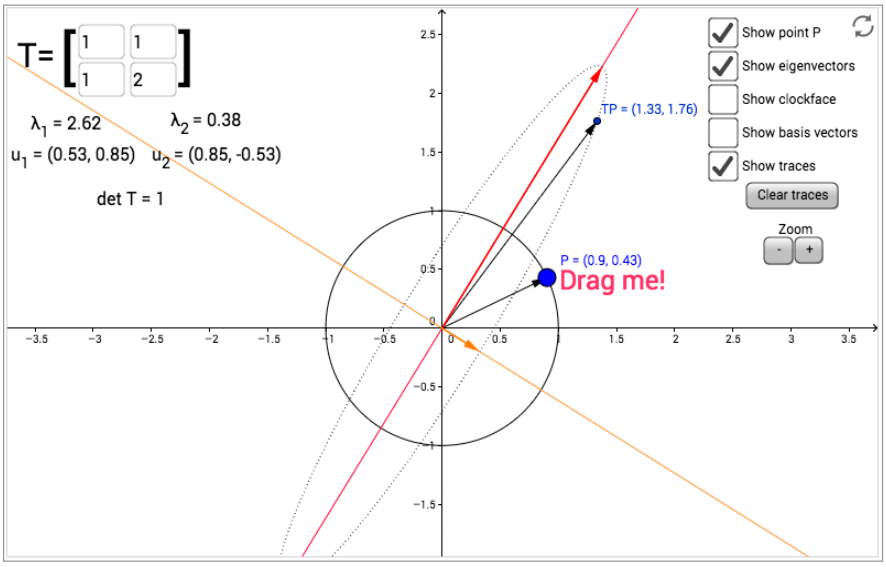


Figure 4 - Applet to teach about linear transformations and eigenvectors

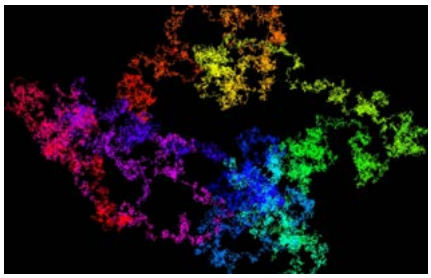


Figure 5 - Walk on the first 100 billion base-4 digits of π

1.09 SEquences and Their Applications (SETA) 2014

The University of Melbourne, 24–28 November 2014

Promoting engagement across key areas involving sequences this conference was attended by leading experts in cryptography, coding theory, quasi-Monte Carlo methods, wireless communication, design theory, discrete mathematics, and number theory. In particular, synergies between mathematicians and engineers were deepened.

National Medal of Science recipient, Distinguished Professor Solomon Golomb's presentation on the importance of sequences research to engineering, communications and radar was a highlight. Particularly his overview of the early history of developments in shift register sequences, a research area he pioneered at the Jet Propulsion Laboratory.

Distinguished Professor Golomb was recently awarded the National Medal of Science, an honour bestowed by the President of the United States to individuals in science and engineering who have made important contributions to the advancement of knowledge in the fields.

The conference included four well received invited talks on contemporary topics in sequences theory and applications.

Professor Kathy Horadam, an eminent mathematician in Hadamard matrices, delivered the first talk. Professor Tor Helleseth presented a proof of Lin Conjecture on two level autocorrelation sequences; Professor Bernhard Schmidt spoke on recent advances in Circulant Hadamard matrices and twisted cyclotomic integers and; Associate Professor Josef Dick presented recent results on the inverse of the star-discrepancy problem and the generation of pseudorandom Numbers. These talks were interesting and well received by conference participants.

The SETA 2014 Program Committee received 36 qualified submissions, with each refereed by at least two experts. The Program Committee selected 24 papers for presentation at the conference and inclusion in the conference proceedings. In addition, the proceedings contain two refereed invited papers; based on the presentations given by Josef Dick and Kathy Horadam, respectively.

Organisers

Associate Professor Udaya Parampalli, The University of Melbourne
Associate Professor Sanming Zhou, The University of Melbourne
Dr Leonie Simpson, Queensland University of Technology
Dr Kai-Uwe Schmidt, Otto-von-Guericke University
Dr Arne Winterhof, Austrian Academy of Sciences

Special presenters

Professor Tor Helleseth, University of Bergen, Norway
Research interests: coding theory, cryptography, sequences and discrete mathematics
Professor Kathy Horadam, RMIT University
Research interests: finite group cohomology, combinatorial design theory, information security, nonlinearity of data and digital sequences, biometrics
Associate Professor Bernhard Schmidt, Nanyang Technological University, Singapore
Research interests: finite geometry, coding theory, algebraic number theory, computing, current projects, circulant weighing matrices, efficient arithmetic over cyclotomic fields and applications to combinatorics
Associate Professor Josef Dick, University of New South Wales
Research interests: numerical integration, in particular, quasi-monte carlo rules, number theory, abstract algebra (finite fields in particular), discrepancy
Distinguished Professor Solomon Golomb, The University of Southern California
Research interests: communications and radar signal design, coding theory and cryptography, combinatorial analysis, number theory, mathematical game theory

MathSciNet Classification

94A55, 05B10, 94B50

Web Links

http://people.eng.unimelb.edu.au/udaya/seta14/

Other Sponsors

The University of Melbourne, AustMS

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1.10 Differential Geometry, Complex Analysis and Lie Theory

La Trobe University, 5–7 December 2014

This event was the second in a series of workshops developed to overcome multi-site communication challenges and the need to promote key work and ideas across a broad geographical area within Australia and overseas. The organising committee developed a three-year program of workshops to be hosted by Australian universities.

A satellite of the Australian/New Zealand Mathematical Society Convention, this year's workshop ran for three days in Melbourne.

Highlights included a series of two-hour lectures by the invited speakers, including Professors Carolyn Gordon, Kang-Tae Kim, Dimitry Millionschikov and Tracy Payne.

Carolyn Gordon gave a survey panoramic talk on Spectral Geometry (in which she is commonly recognised as one of the world's most influential figures). Kang-Tae Kim gave two interrelated lectures on CR geometry. Dimitry Millionschikov presented new results on the geometry of nilmanifolds and Lie cohomology. Tracy Payne gave a brilliant talk on computational methods in the theory of nilpotent Lie algebras.

Australian research was well represented with excellent presentations from Hyam Rubinstein, Thomas Leistner, Wolfgang Globke and Owen Dearricott, with topics ranging from geometry and topology of minimal surfaces to homogeneous Riemannian and pseudo-Riemannian geometry.

The four half-hour talks given by representatives of host universities and two half-hour talks by New Zealand participants were also well received.

AMSI Director, Professor Geoff Prince greeted participants and reiterated the willingness of AMSI to further support national and international collaboration in mathematics.

The main scientific outcomes of this workshop were:

- new directions for future national and international collaboration. An example: plans for two new projects were developed based on discussions with Carolyn Gordon and Tracy Payne
- stronger international standing and reputation of Australian pure mathematics research, in particular in geometry
- international exposure of student and established researcher results
- robust discussion with participants sharing ideas
- undergraduate students benefited from exposure world-class mathematical research and educational opportunities

"This was an excellent conference, with many clear, informative and stimulating talks. There were many experts present and plenty of opportunities to meet and talk. I enjoyed it very much and am looking forward to pursuing the germs of new ideas and understanding planted here."

Workshop participant

Organisers

Dr Yuri Nikolaevsky, La Trobe University
Associate Professor Grant Cairns, La Trobe University
Associate Professor Gerd Schmalz, University of New England
Associate Professor Vladimir Ejov, Flinders University

Special presenters

Professor Carolyn Gordon, Dartmouth College
Research interests: isospectral geometry, isospectral closed Riemannian manifolds
Professor Kang-Tae Kim, POSTECH Mathematics
Research interests: complex analysis of several variables, complex differential geometry and related areas, almost complex structures in relation to symplectic geometry and functional analysis
Professor Dimitry Millionschikov, Moscow State University
Research interest: algebraic topology and its applications, differential geometry and lie theory.
Professor Tracy Payne, Idaho State University
Research interests: geometry and dynamics in the setting of lie groups (especially nilpotent ones) and homogeneous spaces

MathSciNet Classification

53C30, 32M10, 22E25, 32F15, 17B56

Web Links

http://gygeom.com/2014/

Other Sponsors

AustMS, La Trobe University, ARC Project DP 130103485

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1.11 Applied Statistics and Public Policy Analysis Conference (ASPPAC)

Charles Sturt University, 11–12 December 2014

Applied statistics play a vital role in the analysis and evaluation of public policies in various fields including social sciences, economics, health sciences and population studies.

This workshop promoted research collaborations and idea exchange between academics and researchers engaged in applied statistics and public policy research, computational statistics and data analysis methods, and established connections between researchers at tertiary institutions and those working in industry in Australasia. This strengthened connections between research, universities and industry in Australasia.

Topics covered included the role of applied statistics in the evaluation and advancement of public policy; applied statistics in fisheries management; the use statistics to guide policy and evaluate investment projects; aspects of statistics in measuring health and guiding health policy; and theoretical developments in Statistics of use to public policy analysis.

Professor Peter Davis gave an opening address that made the case for advancing public policy through the contributions of applied statisticians and social scientists. Professor You-Gan Wang and several of his students described research into the application of statistics to fisheries management and ecological sustainability. Professor Matthew Gray provided an overview of applied statistics and the evaluation of social policy, and Professor Laurie Brown linked the good health and disability policy through benchmarking for the future with various statistical measures. The final talk was given by Professor Cate D'Este on issues in evaluation of Public Health interventions. More technical talks were given by other speakers.

Organisers

Professor Ken Russell, Charles Sturt University
Dr Azizur Rahman, Charles Sturt University
Dr Cathy Gong, Australian National University

Special presenters

Professor Peter Davis, The University of Auckland
Research interests: development of Statistical Methods, Policy Application within Social and Health Sciences
Professor Laurie Brown, University of Canberra
Research interests: health geography, modelling, microsimulation models, micro-data for investigation of policy issues
Professor Matthew Gray, Australian National University
Research interests: social and economic policy, work and family issues, labour economics, social capital and social inclusion, measuring well-being, the economic consequences of divorce, child support, and social and economic policy development
Professor You-Gan Wang, The University of Queensland
Research interests: statistical methodology for correlated data analysis, robust inferences and model selection and statistical models and data analysis techniques for environmental statistics and natural resource management

MathSciNet Classification

62D05, 62P10

Web Links

http://csusap.csu.edu.au/~azrahman/ASPPAC2014/index.html

Other Sponsors

Charles Sturt University

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1.12 Workshop on Algebraic, Number Theoretic and Graph Theoretic Aspects of Dynamical Systems

University of New South Wales, 2–6 February 2015

Arithmetical dynamical systems, that is, dynamical systems generated by iterations of rational functions over fields of number-theoretic interest, have seen a significant explosion of work in recent years. Despite this recent profusion of scientific activity in ADS, many algebraic, number theoretic and graph theoretic problems remain wide open. Interest in this also comes from connections forged with many different areas of pure and applied mathematics.

The purpose of this workshop was to further explore the complex algebraic and number theoretic behaviour, as well as gain a better understanding of the structure of functional graphs of arithmetical dynamical systems.

The DS_NT_GT Workshop brought together distinguished researchers of different backgrounds (dynamical systems, graph theory and number theory) interested in expanding the scope of problems they investigate and in developing the exciting and versatile research directions in ADS.

The invited speakers had very broad research interests so as to reflect the goal of the workshop. Each invited talk covered several different topics. For example, Professor Cheryl Praeger talked about problems of graph theory, which are related to dynamical systems on graphs (e.g. mixing) and to hot areas of number theory, such as additive combinatorics.

"The combination of the topics was great; there was a lot of variety, and I found it interesting and stimulating to hear what other people investigating dynamical systems work on."

Workshop participant

Professor Tony Guttmann changed the topic of his previously-planned talk to reflect robust discussions and new developments during the workshop.

The workshop was structured to provide plenty of time for informal interaction and networking, which greatly stimulated discussion and resulting in the establishment of collaborative links.

Dr Peter van der Kamp's recent arXiv contribution, Somos-4 and Somos-5 are arithmetic divisibility sequences, relates to work described in his contributed talk, as well as making reference to discussions at the workshop in the acknowledgements as a source of additional knowledge.

Organisers

Professor Brendan McKay, Australian National University
Dr Alina Ostafe, University of New South Wales
Professor John Roberts, University of New South Wales
Professor Igor Shparlinski, University of New South Wales

Special presenters

Professor Alex Gamburd, City University of New York
Research interests: number theory and expander graphs
Professor Tony Guttmann, The University of Melbourne
Research interests: random matrices, lattices, random walks
Professor Cheryl Praeger, The University of Western Australia
Research interests: graph theory and group theory
Professor Klaus Schmidt, University of Vienna
Research interests: ergodic theory and algebraic dynamics
Professor Joe Silverman, Brown University
Research interests: arithmetic dynamics and number theory
Professor Franco Vivaldi, Queen Mary University of London
Research interests: algebraic dynamics and number theory
Professor Thomas Ward, Durham University
Research interests: ergodic theory and algebraic dynamics
Professor Nick Wormald, Monash University
Research interests: graph theory and combinatorics

MathSciNet Classification

11T06, 37P05, 05C20

Web Links

http://web.maths.unsw.edu.au/~jagr/ADS_NT_GT.html

Other Sponsors

AustMS, School of Mathematics and Statistics, University of New South Wales, MASCOS

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1.13 WOMASY - Geometric and Harmonic Analysis meets PDE

Macquarie University, 17 February 2015

The WOMASY group was established by the geometric analysis group at the University of Wollongong; the harmonic analysis group at Macquarie University and the nonlinear analysis group at the University of Sydney. In March 2015, the group expanded to included the University of Newcastle, the Australian National University and the University of New South Wales and changed it's name to the Analysis and PDE group.

The group has two fundamental aims: firstly to meet twice a year to report on research and foster contacts between related research groups in the wider Sydney region and secondly, to give early career researchers the opportunity to speak to a wider audience. These aims increase the research activity between the three participating universities in Sydney and to increase the chance of new job offers for early career researchers.

The 2015 event featured a wide range of topics including:

- *A simplified approach to the regularising effect of nonlinear semigroups* (Dr Daniel Hauber, the University of Sydney)
- *Uniqueness for the biharmonic heat flow on* R^n (Dr Glen Wheeler, University of Wollongong)
- *Singular integrals associated with zygmund dilations* (Dr Ji Li, Macquarie University)
- *Partial differential equations arising in light reflection and optimisation* (Special speaker: Professor Xu-Jia Wang, Australian National University)
- *Fully nonlinear curvature flow of axially symmetric hypersurfaces* (Fatemah Mofarreh, PhD Student, University of Wollongong)
- *Non-linear elliptic equations with isolated singularities* (Dr Florica Cirstea, The University of Sydney)

Organisers

Associate Professor Daniel Daners, The University of Sydney
Professor Xuan Duong, Macquarie University
Dr Daniel Hauer, The University of Sydney
Dr Ji Li, Macquarie University
Associate Professor James McCoy, University of Wollongong
Dr Adam Sikora, Macquarie University
Dr Glen Wheeler, University of Wollongong
Dr Valentina-Mira Wheeler, University of Wollongong

Special presenters

Professor Xu-Jia Wang, Mathematical Sciences Institute, Australian National University
Research interests: partial differential equations, optimal transport problems

MathSciNet Classification

35K92, 35K93, 35B40, 46E30, 58J35

Web Links

www.maths.usyd.edu.au/u/PDESeminar/womasy/index-2015-02.html

Other Sponsors

The University of Sydney, Macquarie University, University of Wollongong

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1.14 4th South Pacific Continuous Optimisation Meeting (SPCOM 2015)

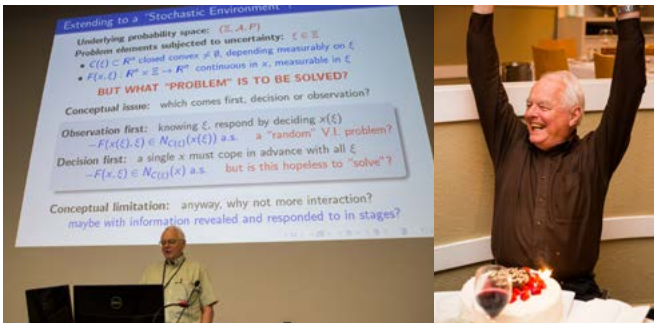
University of South Australia, 8–12 February 2015

This was the fourth edition of the successful South Pacific meetings, following the 2005 and 2010 South Pacific Conferences in Mathematics (SPCM) in Noumea, New Caledonia, and the 2013 South Pacific Optimisation Meeting (SPOM 2013) in Newcastle, Australia. SPCOM 2015 offered a rich scientific program targeted to suit the diversity of attendees from early career to senior researchers. The topics included variational analysis, optimal control theory, convex analysis, numerical optimisation, vector optimisation, stochastic optimisation, functional analysis, and their applications.The meeting started with two tutorials on Sunday 8 February, one in the morning and one in the afternoon. José Mario Martínez delivered the morning tutorial, which was on numerical smooth optimisation. The afternoon tutorial was on numerical non-smooth optimisation, delivered by Claudia Sagastizábal. Both tutorials were free of charge for all registered participants and were indeed very well attended (by 20–25 participants).

Terry Rockafellar, a world leader in convex analysis and optimisation, gave a stellar opening talk showing how Stochastic Variational Inequalities can provide the right framework for studying problems of optimisation and equilibrium in a stochastic setting.

Running over four days, the event included 12 plenary talks, 31 invited talks, and 2 contributed talks. PhD students also had the opportunity to showcase their research and find out more about their peers' research in a poster session. Breakthrough presentations included Radu Boţ's talk illustrating how duality can be exploited for solving complexly structured nonsmooth optimisation problems; Asen Dontchev's address on Lipschitz stability in variational analysis; José Mario Martínez's presentation of new results on optimality conditions for constrained optimisation; and a presentation on first-and second-order necessary conditions for nonlinear programming problems from the viewpoint of exact penalty functions by Xiaoqi Yang. Boris Mordukhovich also impressed with his introduction to a new co-derivative characterisation of maximal monotonicity.

The Fitzpatrick Workshop celebrated the 25th anniversary of the publication of a seminal paper on maximal monotone operators by the late Australian mathematician Simon Fitzpatrick. Fitzpatrick's paper introduced a key tool in functional analysis, with important implications in mathematical optimisation. An objective of this workshop was to understand, after a quarter of a century, what open questions posed in this paper have been solved, and what



"The conference was a spectacular success scientifically and socially, and of course especially for me!"

Emeritus Professor Terry Rockafellar, University of Washington

Organisers

Professor Henri Bonnel, University of New Caledonia
Laureate Professor Jon Borwein, The University of Newcastle
Associate Professor Regina Burachik, University of South Australia
Dr Yalçın Kaya, University of South Australia

Special presenters

Associate Professor Radu Boţ, University of Vienna
Research interests: numerical analysis, operations research, optimisation, mathematical programming
Professor Asen Dontchev, University of Michigan
Research interests: variational analysis, optimisation, optimal control, differential equations, approximation theory
Professor Vaithilingam Jeyakumar, University of New South Wales
Research interests: mathematical optimisation
Professor José Mario Martínez, University of Campinas
Research interests: theory and applications of numerical optimisation
Professor Helmut Maurer, University of Münster
Research interests: theoretical and numerical aspects of optimal control and its applications
Professor Boris Mordukhovich, Wayne State University
Research interests: variational analysis
Professor Jong Shi Pang, University of Southern California
Research interests: operations research, (single and multi-agent) optimisation, equilibrium programming, constrained dynamical systems
Emeritus Professor Terry Rockafellar, University of Washington
Research interests: optimisation theory and related fields of analysis, mathematical finance and risk
Dr Claudia Sagastizábal, National Institute of Pure and Applied Mathematics (IMPA)
Research interests: numerical nonsmooth optimisation and its applications
Emeritus Professor Stephen Simons, University of California, Santa Barbara
Research interests: convex analysis, monotone operator theory
Professor Roger Wets, University of California, Davis
Research interests: variational analysis, stochastic optimisation
Professor Xiao Qi Yang, Hong Kong Polytechnic University
Research interests: mathematical optimisation

Program structure

As well as general conference talks, the event included the Fitzpatrick Workshop, two half-day tutorials and a student poster session.

Other Sponsors

University of South Australia, School of IT and Mathematical Sciences, CIAM, CARMA, University of New Caledonia, AustMS, ANZIAM, ACEMS

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MathSciNet Classification

49, 65, 90

Web Links

http://carma.newcastle.edu.au/meetings/spcom

questions remain open. Stephen Simons gave a keynote talk on Fitzpatrick's contributions to Functional Analysis, introducing a new theoretical framework, which gives a generalisation of Brezis-Browder theorem on linear relations. Most of the results Simons presented are consequences of Simon Fitzpatrick's seminal 1988 paper. Simons' fascinating talk was followed by four 20-minute presentations, given by Adly, Borwein, Boţ, and Burachik.

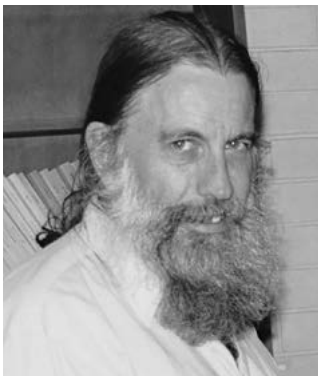
Social events included the joyfully celebrated Terry Rockafellar's 80th birthday on Tuesday during the meeting banquet and a Wineries Tour to McLaren Vale. SIAM and Springer supported the meeting by sending hard copies of books authored by the SPCOM speakers. These books were displayed on desks during the meeting, and then distributed to the students on the last day of the meeting. SIAM made three of these books available electronically, which were given to students as gifts.

Feature: Fitzpatrick Function and its Impact

SIMON FITZPATRICK WAS AN OUTSTANDING AUSTRALIAN mathematician. His contributions have an increasing impact in Functional Analysis, both in theoretical and applied aspects. The now celebrated Fitzpatrick function,

$$F_T(x,x^*)=\sup_{y^*\in T(y)}\langle y^*-x^*,\, x-y\rangle+\langle x,x^*\rangle$$

where T is a maximally monotone map, has been cited and used extensively in wide range of applications from PDEs to modern economic theory. It has become a fundamental tool in maximal monotone theory. The Fitzpatrick function was unnoticed for several years until Martínez-Legaz and Théra rediscovered it in 2001. This function provides a bridge between certain monotone phenomena and convex functions. This allows use of powerful variational techniques for studying problems such as (i) first-order monotone flows, (ii) nonlinear evolutionary PDEs and (iii) quasilinear models in continuum mechanics, electromagnetism and heat conduction. In a surprisingly different field, Flam has recently given an economic interpretation of the Fitzpatrick function in terms of a supply curve, which couples prices to quantities in a non-Walrasian market.



In terms of theoretical advances, the Fitzpatrick function has led to considerable simplifications of the proofs of some classical properties involving maximally monotone operators. For example, Simons and Zalinescu used it to obtain a new and short proof of Rockafellar's charactersation of maximal monotone operators. Within the theory of maximally monotone maps, Burachik and Svaiter used it to define a one-to-one correspondence between a family of convex functions associated with a maximally monotone operator, and a family of enlargements of these operators. These enlargements, in turn, generated a new way for the efficient approximation and analysis of variational inequality problems. Marques Alves and Svaiter have used it recently to define a new constraint qualification ensuring maximality of the sum of maximally monotone operators in non-reflexive Banach spaces.

Stephen Simons opened the Fitzpatrick Workshop with a plenary talk in which, using concepts emanating from Fitzpatrick's work, he obtained a generalisation of Rockafellar's theorem on the maximal monotonicity of subdifferentials, and, among other results, he obtained an extension of Brezis-Browder theorem to non-reflexive Banach spaces (Brezis-Browder theorem proves that, in a reflexive Banach space, the adjoint of a linear monotone mapping with closed graph is monotone if and only if the original mapping is maximally monotone). The plenary talk was followed by four 20-minute talks by Jonathan Borwein, Samir Adly, Radu Boţ and Regina Burachik. Borwein's talk introduced the strong Fitzpatrick inequality and used it to define a gap function for the monotone inclusion problem and variational inequalities. Boţ's talk furnished new duality results for certain convex optimisation problems. Adly showed how non-smoothness naturally arises in dynamical systems, such as those induced by electrical circuits, and some problems from mechanics. Burachik presented a new family of enlargements, which is inspired by Fitzpatrick's 1988 paper and every member of this family is structurally closer to the epsilon-subdifferential enlargement.

Stochastic Variational Inequalities and other Stochastic Problems

Variational inequality modelling, analysis and computations are important for many applications, but most of the subject has been developed in a deterministic setting. In recent years research has proceeded on a track to incorporate stochasticity in one way or another. However, the main focus has been on a rather limited idea of what a stochastic variational inequality might be. Because variational inequalities are especially tuned to capturing conditions for optimality and equilibrium, stochastic variational inequalities ought to provide such service for problems of optimisation and equilibrium in a stochastic setting. Therefore they ought to be able to deal with multistage decision processes involving recourse actions, which has so far hardly been the case. Terry Rockafellar showed that this can be accommodated by bringing in the tools of nonanticipativity and its martingale dualisation. Roger Wets put these new contributions into a historical perspective in his plenary talk, which described the highlights of Terry Rockafellar's results. To reinforce the stochastic flavor, Claudia Sagastizábal's plenary talk was about a new variant of bundle methods, which has "on-demand" accuracy, and Jong Shi Pang's plenary talk concerned Nash equilibria for games with stochastic recourse functions.

Theoretical Aspects of Variational Analysis

The plenary talks by Boris Mordukhovich and Asen Dontchev concerned some important theoretical issues of variational analysis. Mordukhovich discussed a new approach of variational analysis and generalised differentiation to characterisations of maximal monotonicity and strong maximal monotonicity properties for set-valued mappings in both global and local frameworks. Dontchev gave an overview of recent advances in the study of Lipschitz properties of solution mappings, which is of paramount importance in the sensitivity study of constrained optimisation problems.

Theory and Applications of Numerical Optimisation

A common denominator in most talks at SPCOM has been the numerical approaches to several types of optimisation problems. Some talks encompassed theory, some applications, and some others both theory and applications. An example of the latter type was Boţ's plenary talk, which showed us how duality can be exploited for solving complexly structured nonsmooth optimisation problems. Jeya Jeyakumar presented new results in global polynomial optimisation. José Mario Martínez presented new results on sequential optimality conditions for differentiable constrained optimisation. Helmut Maurer spoke about optimal control problems from biology and biomedicine whose solutions exhibit bang-bang and singular control. Xiaoqi Yang presented first-and second-order necessary conditions for nonlinear programming problems from the viewpoint of exact penalty functions. He also presented an interior point method to solve the L_p relaxed penalty problem, together with promising numerical experiments.

1.15 Australia-New Zealand Applied Probability Workshop

Vine Inn Barossa, 7–10 April 2015

This workshop brought together national and international applied probability researchers to present and discuss the state-of-the-art research in this field.

Invited leading international speakers presented challenging topics and some of the latest results in the frontier. New theoretical and methodological contributions to applied probability were discussed. Attendees also attended presentations on the applications of new and existing techniques within epidemiology, ecology, finance, queueing systems and networks.

Associate Professor Dieker's two-part talk *Change of Measure: A Love Story*, focused on research efforts where the "change of measure" technique was instrumental in the development of new theorems and simulation algorithms. The talk was well received by an audience able to share their own success stories of the technique.

Associate Professor Olvera-Cravioto also presented a two-part talk titled *Queues in the Cloud: Generalising the Single Server Queue to Massively Parallel Networks*. Her talk focused on a queueing model motivated by cloud computing capabilities in large server farms. The immediate application and intricate mathematics in her work were widely doscissed among participants.

Both speakers are well known in their area and they gave particularly inspiring talks.

Organisers

Professor Nigel Bean, University of Adelaide
Dr Andrew Black, University of Adelaide
Professor Jeffrey Hunter, Auckland University of Technology
Professor Fima Klebaner, Monash University
Dr Yoni Nazarathy, The University of Queensland
Dr Giang Nguyen, University of Adelaide
Professor Phil Pollett, The University of Queensland
Dr Leonardo Rojas-Nandayapa, The University of Queensland
Dr Joshua Ross, University of Adelaide
Professor Peter Taylor, The University of Melbourne
Professor Ilze Ziedins, The University of Auckland

Special presenters

Associate Professor Ton Dieker, Georgia Tech/ Columbia University
Research interests: applied probability, stochastic networks and stochastic analysis of algorithms
Associate Professor Mariana Olvera-Cravioto, Columbia University
Research interests: asymptotic analysis involving heavy-tailed distributions, analysis of information ranking algorithms and their large-scale behaviour, asymptotic properties of solutions to certain stochastic recursions, in particular, weighted branching processes

MathSciNet Classification

60K20, 60J20, 60J28

Web Links

http://maths.adelaide.edu.au/ANZAPW15

Other Sponsors

ACEMS, ANZIAM, University of Adelaide

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1.16 Symmetries and Spinors: Interactions between Geometry and Physics

University of Adelaide, 13–17 April 2015

The interplay between physics and geometry has enriched the internal structure of both fields leading to stunning advances. This is vividly exemplified in the theory of supergravity, which is a super-symmetric extension of Einstein's relativity theory to the small scales governed by the laws of quantum physics.

Sophisticated mathematics is being employed to finding solutions to the generalised Einstein equations and in return, they provide a rich source for new exotic geometries. This workshop revolved around the construction of supergravity models and related mathematical techniques. An eventual answer to this question amounts to a huge leap in our understanding of nature, and will open up countless opportunities for future research and discoveries.

Bringing together leading Australian supergravity researchers, mathematicians and physicists, the event showcased state-of-the-art research within the field through a series of presentations and discussions. Providing cross-discipline insights, the event also strengthened connections between the Australian and International research communities.

The famous Einstein equations describe the gravitational force as a result of the curvature of space-time. The classical theory of gravitation is well suited to phenomena on large scales, but it cannot be applied to the small scales of the quantum world. Supergravity theories emerged in the 1980s as an attempt to extend Einstein's equations to scales where quantum gravitational effects cannot be neglected. It is an ingredient of the modern superstring/M-theory, aiming to provide a mathematical framework for the study of all elementary particles and interactions.

Extending the Einstein equations introduces a supersymmetric component, a solution to which requires the existence of Killing spinors in the given supergravity model. The first models were based on eleven-dimensional space-times, but in the following years models in lower dimensions were developed.

Today it is a highly active area of research, and the emergence of new

models continuously increases our possibilities to construct realistic models. Another remarkable property of supersymmetry is that it allows for the energy-momentum operator of the system to be factorised into a square of a so called supercharge operator. This has profound implications for the stability and regularity of the quantised model, but more unexpectedly, the supercharge operator can at times be used to evaluate the path integral via localisation techniques. This method has witnessed a remarkable expansion in the last decade, building on the successful work of Witten, Nekrasov and Pestun.

The scientific outcomes of the workshop were very satisfying. All talks were of high pedagogical quality and ideally suited to meet our aims. The discussions in the breaks and even during the talks showed that the audience was engaged. Mathematicians and physicists gained insights into each other's work and built connections between the Australian research community and world-class researchers from overseas.

Organisers

Professor Peter Bouwknegt, Australian National University
Dr Wolfgang Globke, University of Adelaide
Dr Pedram Hekmati, University of Adelaide
Dr Thomas Leistner, University of Adelaide

Special presenters

Professor José Figueroa-O'Farrill, The University of Edinburgh
Research interests: string theory and supersymmetry; the geometry of supergravity backgrounds

Professor Maxim Zabzine, Uppsala University
Research interests: mathematical physics, vertex algebras, application of differential geometry in low dimensional quantum field theories, supersymmetric localisation techniques

MathSciNet Classification

53C50, 83C60, 83E50, 83E30, 53C30

Web Links

www.iga.adelaide.edu.au/workshops/April2015/

Other Sponsors

Mathematical Institute at the Australian National University, Institute for Geometry and its Applications at the University of Adelaide

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1.17 Workshop on Continuous Optimisation: Theory, Methods and Applications

Federation University Australia, April 16–17 2015

This year's event was dedicated to the late Professor Alexander Rubinov. As founding director of the University of Ballarat's Centre for Informatics and Applied Optimisation, Professor Rubinov made a significant contribution to optimisation theory and in particular to nonsmooth and global optimisation. He closely collaborated with colleagues from other Australian and overseas universities. Professor Rubinov organised several Australian Optimisation Day workshops at the University of Ballarat and also the 6th International Conference on Optimisation: Techniques and Applications.

In April, leading Australian continuous optimisation experts and practitioners gathered at Federation University Australia to explore all areas of continuous optimisation and optimal control. The workshop provided excellent opportunities for discussion among participants on new findings and possible collaborations. It was also an excellent opportunity for PhD students to meet leading Australian experts in optimisation and control theory.

The presentations covered different areas of continuous optimisation and its applications. Topics included variational analysis, optimisation theory, numerical optimisation, control theory, set-valued analysis and application areas such as data mining and artificial intelligence, optimisation of water distribution systems and engineering.

A special session showcased achievements of the Centre for Informatics and Applied Optimisation, Faculty of Science and Technology, Federation University Australia.

Organisers

Professor Andrew Eberhard, RMIT University
Associate Professor Adil Bagirov, Federation University Australia
Associate Professor Alex Kruger, Federation University Australia
Associate Professor David Yost, Federation University Australia
Dr Musa Mammadov, Federation University Australia
Dr Julien Ugon, Federation University Australia
Dr Nadia Sukhorukova, Swinburne University of Technology
Dr Zari Dzalilov, Federation University Australia
Helen Wade, Federation University Australia

Special presenters

Laureate Laureate Professor Jon Borwein, The University of Newcastle
Research interests: pure and applied mathematics, computer science, optimisation and variational analysis
Professor Kok Lay Teo, Curtin University of Technology
Research interests: control theory, computational methods for optimal control & optimisation, financial portfolio optimisation, operations research, signal processing in telecommunications engineering

MathSciNet Classification

90C30, 90C26, 90C46

Web Links

http://federation.edu.au/faculties-and-schools/faculty-of-science-and-technology/research/ciao/events/16-17-apr-2015-workshop-on-continuous-optimization

Other Sponsors

Federation University Australia

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Participants at the Robust Statistics and Extremes Conference held at the Australian National University

Professor Xiao Qi Yang presenting at the 4th South Pacific Continuous Optimisation Meeting (SPCOM 2015)

Professor Michael Barnsley presenting at the EViMS Workshop on the Effective Use of Visualization in the Mathematical

1.18 Workshop on Mathematics and Computation

The University of Newcastle, 19–21 June 2015

This three-day workshop covered an outstanding program with four sessions exploring formal and computer assisted proof, computational theory, computational group theory, computational number theory and computer assisted discovery.

Sessions were organised as follows:

- Formal proof and computer-assisted proof. Jeremy Avigad and his student Rob Lewis gave an impressive summary of the current state of formal proof techniques. Avigad was responsible for the formal proof of the prime number theorem. After this Cris Calude lectured on quantum indeterminancy and connecting a variety of notions of uncertainty and incompleteness.

- Computational group theory. John Cannon, the founder of the MAGMA group, presented an overview of the current status of computational group theory while lecturing on the classification theory for finite simple groups. Don Taylor then gave a wonderful lecture in celebration of the 50th anniversary of the discovery at ANU of the Janko (sporadic simple) group, and its importance to the classification of finite simple groups.

- Computational number theory and related topics. This session had two local keynote speakers. Wadim Zudilin gave a fascination lecture on multi-zeta values while Richard Brent (ANU and CARMA) then spoke on the asymptotics of various number theoretic functions.

- Computer-assisted discovery. The final session began with a talk by Pablo Moscato, a Newcastle bioinformatics expert, on current algorithms for handling big data. It ended with a lecture by Jon Borwein on short random walks that highlighted the role of computation (numeric, symbolic and graphic) in mathematical discovery.

Organisers

Laureate Professor Jon Borwein, The University of Newcastle
Professor Jeremy Avigad, Carnegie Melon University

Special presenters

Professor Jeremy Avigad, Carnegie Mellon University
Research interests: mathematical logic, proof theory, philosophy of mathematics, formal verification, automated reasoning, and the history of mathematics
Professor Cristian Calude, The University of Auckland
Research interests: algorithmic information theory and quantum physics
Professor John Cannon, The University of Sydney
Research interests: algebra, number theory, algebraic geometry and algebraic combinatorics
Associate Professor Don Taylor, The University of Sydney
Research interests: computations with groups, combinatorics and representation theory, particularly permutation groups and associated "geometric" structures

MathSciNet Classification

03B870, 11Y99, 20F16

Web Links

https://carma.newcastle.edu.au/meetings/mathsandcomputation/

Other Sponsors

CARMA

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"AMSI research workshops provide fertile environments to sow the seeds for research innovation and excellence. Encouraging the exchange of ideas as well as national and global collaboration, these events deliver training and development to foster future research leaders."

Professor Terence Tao, UCLA

Lecture Series 2

2.0 Lecture Series—Overview

Our world-class national tours, specialist lectures and outreach events stimulate discussion and collaboration at the cutting-edge of the mathematical sciences. Both challenging and inspiring, the opportunity to engage with international field experts delivers an enhanced research experience for students, early career and established mathematical scientists.

Lecture Series

"I do my research because there are mathematical questions out there. And these questions are worth answering. I believe that 50 to 100 years from now, the maths we are developing now people will find uses for."

Hanna Neumann Lecturer 2014 Dr Nina Snaith, University of Bristol

2.1 2014 AMSI-SSAI Lecturer

19 August–20 November 2014
Professor Terry Speed, Walter and Eliza Hall Institute of Medical Research

The annual AMSI Lecture Tour sponsors eminent international researchers to visit Australia, giving the research community and the general public an opportunity to hear from top researchers in the fields of mathematics and statistics.

Biography

Professor Terry Speed is a Senior Principal Research Scientist and Lab Head within the Walter and Eliza Hall Institute of Medical Research's BioInformatics Division. An associate of the School of Mathematics and Statistics at the University of Melbourne, he remains an affiliate with the Department of Statistics of the University of California at Berkeley, where he taught for many years. As well as mentoring graduate students and postdocs in statistics and bioinformatics, he is co-investigator on genetic, genomic and bioinformatics projects. He also serves on a number of scientific advisory boards, including those of Veracyte Inc, a Bay area diagnostics company, Cancer UK's Cambridge Institute, and the Wellcome Trust Center for Human Genetics in Oxford.

Professor Speed is recognised as one of the world's leaders in the relatively new field of bioinformatics. He has more than 40 years of experience in statistics, specialising in the design and analysis of studies in genetics and genomics. He was awarded the 2002 Pitman Medal (Statistical Society of Australia), the 2003 Moyal Medal (Macquarie University), and was the joint recipient of 2004 Outstanding Applications Paper Award, American Statistical Association. A Fellow of the Australian Academy of Sciences, Professor Speed was recently elected as a Fellow of the Royal Society of London, and in 2013 he was awarded the Australian Prime Minister's Prize for Science.

Abstracts:

Removing Unwanted Variation from High-throughput Omic Data

(joint with Johann Gagnon-Bartsch and Laurent Jacob)

Over the past few years many microarray-based gene expression studies involving a large number of samples have been carried out, with the hope of understanding, predicting or discovering factors of interest such as prognosis or the subtypes of a cancer. The same applies to proteomic and metabolomic data, and to other kinds of data. Such large studies are often carried out over several years, and may involve several hospitals or research centres. Unwanted variation (UV) can arise from technical aspects such as batches, different platforms or laboratories, or from biological signals such as heterogeneity in ages or different ethnic groups which are unrelated to the factor of interest in the study. This can easily lead to poor results. Recently, we proposed a general framework to remove UV (called RUV) in microarray data using control genes. It showed good behaviour for differential expression analysis (i.e. with a known factor of interest) when applied to several datasets, in particular better performance than state-of-the-art methods such as Combat or SVA. This suggests that controls can indeed be used to estimate and efficiently remove sources of unwanted variation. The methods are illustrated on a variety of kinds of omic datasets.

Normalisation of RNA-Seq Data: Are the ERCC Spike-In Controls Reliable?

(joint with Sandrine Dudoit, Davide Risso and John Ngai)

The External RNA Control Consortium (ERCC) developed a set of 92 synthetic polyadenylated RNA standards that mimic natural eukaryotic mRNA. The standards are designed to have a wide range of lengths (250–2000 nucleotides) and GC-contents (5–51%). The ERCC standards can be spiked into RNA at various concentrations prior to the library preparation step and serve as negative and positive controls in RNA-Seq. Ambion commercialises spike-in control mixes, ERCC ExFold RNA Spike-in Control Mix 1 and 2, each containing the same set of 92 standards, but at different concentrations. We investigate the use of the ERCC spike-in controls for two main purposes: (a) Quality assessment/quality control (QA/QC) of RNA-Seq data and benchmarking of normalisation and differential expression (DE) methods, and (b) Direct inclusion in between-sample Normalisation procedures. We have two RNA-seq data sets which make use of the ERCC controls: a local one concerning treated and untreated zebra fish tissue, and some of the SEQC samples. A variety of normalisation methods will be compared, both using and not using the ERCC controls. One of the methods we discuss is a variant on our recently published RUV-2 method, which uses SVD on negative controls.

Lecture tour dates 2015

DATE	TITLE	VENUE	STATE
19 August	Public Lecture - A New Frontier: Understanding Epigenetics Through Mathematics	Swinburne University of Technology	VIC
20 August	ACE Seminar: Comparing and Combining Mutation Callers	The University of Melbourne	VIC
26 August	Seminar: Removing Unwanted Variation from High-throughput Omic Data	Australian Bureau of Statistics	ACT
27 August	Public Lecture - A New Frontier: Understanding Epigenetics Through Mathematics	Australian National University	ACT
22 September	Seminar: Removing Unwanted Variation from High-throughput Omic Data	Western Sydney University	NSW
23 September	Public Lecture - A New Frontier: Understanding Epigenetics Through Mathematics	UNSW Australia	NSW
24 September	Seminar - Comparing and Combining Mutation Callers	The University of Sydney	NSW
25 September	Public Lecture - A New Frontier: Understanding Epigenetics Through Mathematics	Charles Sturt University	NSW
8 October	ACE Seminar: A Normalisation of RNA-Seq Data: Are the ERCC Spike-In Controls Reliable?	The University of Western Australia	WA
9 October	Public Lecture - A New Frontier: Understanding Epigenetics Through Mathematics	The University of Western Australia	WA
16 October	Public Lecture - A New Frontier: Understanding Epigenetics Through Mathematics	University of Tasmania	TAS
16 October	Seminar: Removing Unwanted Variation from High-throughput Omic Data	University of Tasmania	TAS
30 October	Public Lecture - A New Frontier: Understanding Epigenetics Through Mathematics	Queensland University of Technology	QLD
20 November	Seminar: Removing Unwanted Variation from High-throughput Omic Data	University of Adelaide	SA
20 November	Public Lecture - A New Frontier: Understanding Epigenetics Through Mathematics	University of Adelaide	SA

Comparing and Combining Mutation Callers

(joint with Su Yeon Kim and Laurent Jacob)

Somatic mutation-calling based on DNA from matched tumour-normal patient samples is one of the key tasks carried by many cancer genome projects. One such large-scale project is The Cancer Genome Atlas (TCGA), which is now routinely compiling catalogues of somatic mutations from hundreds of paired tumour-normal DNA exome-sequence datasets. Several mutation-callers are publicly available and more are likely to appear. Nonetheless, mutation-calling is still challenging and there is unlikely to be one established caller that systematically outperforms all others. Evaluation of the mutation callers or understanding the sources of discrepancies is not straightforward, since for most tumour studies, validation data based on independent whole exome DNA sequencing is not available, only partial validation data for a selected (ascertained) subset of sites.

We have analysed several sets of mutation calling data from TCGA benchmark studies and their partial validation data. To assess the performances of multiple callers, we introduce approaches utilising the external sequence data to varying degrees, ranging from having independent DNA-seq pairs, RNA-seq for tumour samples only, the original exome-seq pairs only, or none of those.

Utilising multiple callers can be a powerful way to construct a list of final calls for one's research. Using a set of mutations from multiple callers that are impartially validated, we present a statistical approach for building a combined caller, which can be applied to combine calls in a wider dataset generated using a similar protocol. The approach allows us to build a combined caller across the full range of stringency levels, which outperforms all of the individual callers.

Public Lecture - A New Frontier: Understanding Epigenetics Through Mathematics

Having mapped the human genome, the next frontier is understanding human epigenomes—the 'instructions' which tell the DNA whether to make skin cells or blood cells or other body parts. Apart from a few exceptions, the DNA sequence of an organism is the same whatever cell is considered. So why are the blood, nerve, skin and muscle cells so different and what mechanism is employed to create this difference? The answer lies in epigenetics. If we compare the genome sequence to text, the epigenome is the punctuation and shows how the DNA should be read. Advances in DNA sequencing in the last five years have allowed large amounts of DNA sequence data to be compiled. For every single reference human genome, there will be literally hundreds of reference epigenomes, and their analysis could occupy biologists, bioinformaticians and biostatisticians for some time to come.

Interview with Terry Speed

Leading BioInformaticist and Walter and Eliza Hall Principal Research Scientist, Professor Terry Speed sat down with AMSI to chat about his latest research, mathematics in medical science and mentoring the next generation of innovators.

What do you find most exciting about your current research?

One of the areas that I'm really interested in these days is Epigenetics. Beyond the DNA, it's responsible for providing initial guidance to an organism or cell to trigger things such as reading the DNA and converting it into proteins. In some sense, it's going sort of one step behind. We think the DNA's got all the stories, but of course there's a story behind the story, and much of the interest in science is sort of peeling back the layers. We typically think about Epigenetics in terms of gene regulation—what gene goes on/off and when they go on/off. It's complicated because we have many times in the life of an organism and we have many sorts of cells in the body of a complex organism. It's almost an infinitely complex mosaic to understand, but it has lots of challenging statistical problems and it's fun biology as well. For example, the impact of diet—you feed a worker bee royal jelly and you convert it into a queen bee. Diet alone changes the way in which the genes are expressed. It was originally sterile, it becomes fertile and is able to lay eggs—a pretty dramatic change just from eating some jelly.

How are you using statistics to make sense of epigenetic data?

One of the topics that I study is Methylation, which is a modification of DNA that plays an important role in expression of genes and that can happen across the entire genome. When you modify, obviously you're interested in finding out exactly where it's been modified and how differences of these modifications may play a role. So there's a general topic or the identification of differentially methylated regions—DMRs. Lots of challenging issues there. There's serial correlation in the methylation mark along the genome—quite complex and it mixes in with a lot of genome structure. So, just a simple task of finding which regions are differentially methylated in Cell Type 1 from Cell Type 2—that's already quite a host in interesting statistical challenges.

Are there other areas outside of medical research that excite you?

I get excited about lots of different things at different times, but one of the things that I'm really interested in is low probabilities. You'll see low probabilities quoted when people talk about risks and want to say that they're very certain, say of a DMR identification. When you have very little data, as you typically do with these low probabilities, all sorts of interesting and often quite phony methods get developed to produce answers. So, if you'd like one interest, not in any sense a major one, is just getting to the bottom of what people do and how right or how wrong it is when you're at the limits of the amount of data you've got. For example, if you want to say something happens one in a million times, how do you get data to make that a solid statement?

How important is collaboration in your research?

I think the short answer is 'very important', even right back when I was doing my PhD. I used to say that I'm a social mathematician, in the sense that I like talking to a lot of people about my work. I'm not that interested in chugging away in total isolation. I need to interact with people, and in a scientific environment, it's a natural thing to do. With mathematicians, sometimes they collaborate in the sense that they both contribute to the same problem. It's a lot easier in science because you bring different skills to the same issue. In mathematics, perhaps it's less so—often you have the same sort of skills and you just carve up the problem in different ways. Anyway, short answer, it's very important to me because I don't like working on my own.

Mathematicians and statisticians are often depicted as boring number crunchers. How can we address this image problem?

We just have to get out there. We have to be involved, not be background people but be involved a little bit more in the front as appropriate. When you look at physicists or computer scientists, my impression is they tend to be less shrinking violets than mathematicians and statisticians. We probably think we worry about the details more than bigger picture people. I'm not speaking against details, but you shouldn't let concern for details inhibit you getting involved in bigger picture things. Have confidence that we, in the statistical and the mathematical world, have something to contribute—dive in and then be careful, but don't be careful before you dive in.

When you were a student, who were your scientific heroes?

I really had one above all others and that was R.A. Fisher, the statistician and geneticist who worked in evolution. I did a third year Honours project about his work and learned a lot about it in my courses. Somehow Fisher just stood out. He was known to geneticists as a great geneticist, known to statisticians as a great statistician, known to evolutionary biologists as a great evolutionary biologist. That covered a breadth of my interests as an undergraduate and they're still very close to my major interests now. There are other people—Darwin, the Huxleys—people who are involved in evolution are also very important to me.

What attracted you to numerical mathematics over other sciences?

It was basically by elimination. I didn't find experimental science to my liking. Experiments are great in theory. In practice, I was frustrated. I think I have this idea of the world, an almost a platonic view that things ought to be perfect. When you do a chemistry or physics experiment, it almost never comes out perfectly. So a desire for perfection or a frustration with the imperfections of the real world led me to this more abstract and more perfect world. Of course, I'm also interested in applying the abstract and perfect stuff to the real world, but it's a slightly different activity than doing experiments. So I think I'm a refugee from experimental science.

What makes a good teacher?

Enthusiasm is the number one characteristic. Teachers have got to get you interested in what they're talking about. For a good student—even a teacher who's occasionally wrong—if they're interesting, they get you hooked. Obviously you'd hope that you'll pick up mistakes if they do have them, but above all, enthusiasm. No matter how accurate, dry and boring teaching is not the way to excite and interest young people, in my view.

You're a keen advocate for gender equity here at the Walter and Eliza Hall Institute of Medical Research. What do you think we could to improve female participation in maths-related professions?

Being a male, I tend to focus on the things where the males are possibly at fault or at least things men can do. There are lots of institutional structural barriers to women succeeding in so-called STEM discipline—Science, Technology, Engineering and Mathematics. I think men run the show in most of these areas, so it's a change in the attitudes of men that is going to be a major part of changing the situation for women. Being a man and being a supporter of this change, I think I've got a role to play. Clearly women have a role to play as well, but it's not for me to tell them how to live their lives. But if I see men who are being obstructive, conservative or narrow-minded and don't look beyond their immediate male counterparts, I'm very happy to speak up and condemn this sort of activity—trying to move towards a more equitable way of, as it were, involving the human race in mathematics and other disciplines.

You've been a researcher for over 40 years, has there been a particular highlight/ achievement that you're most proud of?

I'm never very good with a question like that. You look back and you think, "Gee, that was kind of nice" or "How on earth did that idea come?" Usually I'm thinking about the future, not the past. Pointing to something and saying, "Oh yeah that could be great satisfaction, I'll rest on my laurels" is not my style. Your legacy—that's for other people to decide. I'll look to the future and hope I can do something that is better than anything I've done in the past. That seems to be a reasonable goal.

"I'm not speaking against details, but you shouldn't let concern for details inhibit you getting involved in bigger picture things. Have confidence that we, in the statistical and the mathematical world, have something to contribute—dive in and then be careful, but don't be careful before you dive in."

2.2 ACE National Seminar Series

AMSI runs a national Advanced Collaborative Environment (ACE) seminar series in partnership with AustMS, ANZIAM, SSAI, ANZAMP and ASOR. Featuring leading Australian and international field experts, the series includes a range of accessible and very high quality seminars for the broader mathematical community in Australia.

The C*-algebras of Right-Angled Artin-Tits Monoids

7 July 2014, University of Wollongong

Professor Søren Eilers

Biography: Professor Søren Eilers received his PhD from the University of Copenhagen in 1995. He was appointed immediately to an assistant professorship at Copenhagen, and was promoted to full Professor in 2008. He has held numerous visiting positions at international institutions like the Fields Institute in Toronto, the Mittag-Leffler institute in Stockholm, and MSRI at Berkeley, and was the president of the Danish Mathematical Society from 2006 to 2008. Søren's research interests lie primarily in the areas of symbolic dynamics and of operator algebras. He has contributed to the study of invariants for symbolic-dynamical systems, to the theory of stability of relations for C*-algebras, and to C*-algebraic representation theory for various sorts of dynamical systems. In recent years, Søren has instigated a program of classification of non-simple C*-algebras by K-theoretic invariants. This program has taken great strides forward and is now a major international research focus which continues to grow apace.

Abstract: The right-angled Artin groups and semigroups are defined from undirected graphs by associating a generator to each vertex, and imposing commutativity on a pair of generators exactly when they are connected by an edge. In a completely similar vein, one can study operators on Hilbert spaces which are required to commute according to data arising from the graph. Recent insight has clarified the sense in which this latter definition is founded on the former for semigroups.

Employing classification theory for non-simple C*-algebras, we have obtained a complete description of these right-angled Artin semigroup C*-algebras by their K-theory, which reflects the geometry of the graph through the Euler characteristic. Among many other things, this leads to surprisingly strong results on the stability of such operators, showing that if a family of operators satisfy the relevant relations up to a small error, then they can be perturbed a bit to obtain an exact match.

This is joint work with Xin Li and Efren Ruiz.

Experts, Judgements and Intelligence

12 September 2014, AMSI

Professor Mark Burgman

Biography: Mark Burgman is Managing Director of the Centre of Excellence for Biosecurity Risk Analysis, the Adrienne Clarke Chair of Botany in the School of Botany at the University of Melbourne and Editor-in-Chief of the journal Conservation Biology. He works on ecological modelling, conservation biology and risk assessment. His research has included models on a broad range of species and a range of settings including marine fisheries, forestry, irrigation, electrical power utilities, mining, and national park planning. He received a BSc from the University of New South Wales (1974), an MSc from Macquarie University, Sydney (1981), and a Ph.D. from the State University of New York (1987). He worked as a consultant ecologist and research scientist in Australia, the United States and Switzerland during the 1980's before joining the University of Melbourne in 1990.

Abstract: Expert judgements often are repudiated in science as subjective and unreliable. Unfortunately, often they are all we have.

The growth in Bayesian inference has renewed interest in the estimation of priors. The notion of expert judgement is broader than that, encompassing judgement-based specification of model parameters, distributional shapes, functions and dependencies, as well as a host of other assumptions. This presentation argued that expert judgement should be afforded the same rigour as currently afforded to data. It outlines approaches to acquiring, validating and improving expert opinions and subjective estimates. It finishes with an assessment of these methods applied to geopolitical intelligence gathering.

Number of rooms connected: 4

ACE National Seminar Conveners

SOCIETY	TOPIC	CONVENER
AustMS	Pure Mathematics	Professor Aidan Sims
ANZIAM	Applied Mathematics	Professor Matthew Simpson
ANZAMP	Mathematical Physics	Professor Jonathon Kress
SSAI	Statistics	Associate Professor Scott Sisson
ASOR	Optimisation	Dr Paul Gaertner

Advanced Collaborative Environment (ACE) Network

In 2015, AMSI launched the Advanced Collaborative Environment (ACE) network. Replacing the Access Grid Room (AGR) Network, ACE has strengthened engagement within the Australian and international mathematical sciences communities. The new, sophisticated Visimeet software has improved functionality and reliability of the remote teaching and research collaboration network. The full program of ACE events resumed from mid-2015.

Computing Series

Laureate Professor Jon Borwein

Biography: Jonathan M. Borwein FRSC, FAA, FAAAS, FBAS, FAustMS, FAMS is Laureate Professor in the School of Mathematical and Physical Sciences and Director of CARMA, the Priority Research Centre in Computer Assisted Research Mathematics and its Applications at the University of Newcastle. An ISI highly cited scientist and former Chauvenet prize winner, he has published widely in various fields of mathematics and computing, including optimisation, computational number theory, classical and functional analysis. He is a past president of the Canadian Mathematical Society and is currently co-editor in chief of the Journal of the Australian Mathematical Society.

Professor David Bailey

Biography: David H. Bailey is a Senior Scientist (retired), Computational Research Department, Lawrence Berkeley National Laboratory, and Research Fellow, Department of Computer Science, University of California, Davis. He is a leading figure in the field of high-performance scientific computing, with research ranging from numerical algorithms to supercomputer performance studies. He has received the Sidney Fernbach Award from the IEEE Computer Society, the Gordon Bell Prize from the Association for Computing Machinery, and the Test of Time Award from the ACM/IEEE Supercomputing Conference. Bailey is also a leading figure in the field of computational and experimental mathematics, applying high performance computing to problems in research mathematics. He is author or co-author of five books and over 100 papers in this field, many of them in conjunction with his long-time collaborator Jonathan M. Borwein of the University of Newcastle, Australia. Bailey has received the Chauvenet Prize and the Merten Hesse Prize from the Mathematical Association of America.

Big Data Computing: Science and Pseudoscience

11 July 2014, The University of Newcastle

Professor David Bailey & Laureate Professor Jon Borwein

Abstract: The relentless advance of computer technology, a gift of Moore's Law, and the data deluge available via the Internet and other sources, has been a gift to both scientific research and business/industry. Researchers in many fields are hard at work exploiting this data. The discipline of "machine learning," for instance, attempts to automatically classify, interpret and find patterns in big data. It has applications as diverse as supernova astronomy, protein molecule analysis, cybersecurity, medicine and finance. However, with this opportunity comes the danger of "statistical overfitting," namely attempting to find patterns in data beyond prudent limits, thus producing results that are statistically meaningless.

The problem of statistical overfitting has recently been highlighted in mathematical finance. A just-published paper by the present author, Jonathan Borwein, Marcos Lopez de Prado and Jim Zhu, titled *Pseudo-Mathematics and Financial Charlatanism*, draws into question the present practice of using historical stock market data to "backtest" a new proposed investment strategy or exchange-traded fund. We demonstrate that in fact it is very easy to overfit stock market data, given powerful computer technology available, and, further, without disclosure of how many variations were tried in the design of a proposed investment strategy, it is impossible for potential investors to know if the strategy has been overfit. Hence, many published backtests are probably invalid, and this may explain why so many proposed investment strategies, which look great on paper, later fall flat when actually deployed.

In general, we argue that not only do those who directly deal with "big data" need to be better aware of the methodological and statistical pitfalls of analysing this data, but those who observe these problems of this sort arising in their profession need to be more vocal about them. Otherwise, to quote our "Pseudo-Mathematics" paper, "Our silence is consent, making us accomplices in these abuses."

Number of rooms connected: 7

Fooling the Masses: Reproducibility in High-performance Computing

15 July 2015, The University of Newcastle

Professor David Bailey & Laureate Professor Jon Borwein

Abstract: Reproducibility is emerging as a major issue for highly parallel computing, in much the same way (and for many of the same reasons) that it is emerging as an issue in other fields of science, technology and medicine, namely the growing numbers of cases where other researchers cannot reproduce published results. This talk will summarise a number of these issues, including the need to carefully document computational experiments, the growing concern over numerical reproducibility and, once again, the need for responsible reporting of performance. Have we learned the lessons of history?

Number of rooms connected: 8

Interview with Dr Nina Snaith

As she prepared for speaking duties at AustMS 2014, AMSI caught up with internationally distinguished senior mathematics academic Nina Snaith.
The University of Bristol based researcher opened up about growing up mathematical, challenges facing women in the field and her work on statistical properties of L-functions and Random Matrix Theory (RMT).
Born in London, Nina grew up in Canada where she attended McMaster University completing an undergraduate degree in theoretical physics.
In the late 90s her interest in RMT saw her migrate back to the United Kingdom to begin her PhD research with Jon Keating. Nina completed her thesis, Random Matrix Theory and Zeta Functions, in 2000 at the University of Bristol.

Nina's work is a good example of the two-way relationship between mathematics and physics. She explores the rich mathematical structure of RMT and continues to be fascinated by the connections it has with pure mathematics, even though the more intuitive links are with fundamental physics and engineering.

AMSI runs a Vacation Research Scholarship program over summer; I believe you participated in something similar?

I did. During these summer internships I realised how much I love learning and investigating new things. This experience is so different from learning material for assessment, such as an exam. I did three such projects throughout my time at McMaster; the first was in a molecular biology lab, the second was concerned with solid-state physics, but it was the final project that I did in theoretical physics that introduced me to random matrix theory. These projects showed me what it was like to study independently. If you want to see if research suits you, there is no better way than by doing a project like this, either in a summer or as part of an undergraduate program.

"Mathematics in Schools" is a course you designed at Bristol, what was the idea behind it and who benefits?

Our undergraduates have a placement in a local school in a maths class. They act as a role model for the students, provide support for the teachers and gain valuable experience for themselves about teaching maths and working in a school environment. So, it benefits everyone involved. Because our students have chosen to study mathematics at university they are enthusiastic about it; this can help spark the interests of the school students.

You studied at McMaster University in Canada, what took you to Bristol?

I did my final year undergraduate project at McMaster on quantum chaos, which links with random matrix theory, the field I now work in. I knew I wanted to continue in the same sort of area, so I asked my project supervisor to suggest some names of people I could do a PhD with. I wrote to several mathematicians and physicists and the advisor I chose, Jon Keating, wrote me the nicest email. He used the phrase "don't fret" when I was worried about having a background in physics instead of maths. I figured anyone who used that phrase had to be lovely!

A solid mathematics background is needed in many jobs; have your peers chosen other professions?

Software development and finance seem to have been popular career choices for my postgraduate peers. Also, many have continued in research or teaching mathematics in various environments and at various levels. But basically it prepares you for anything that doesn't need honing of a specific skill, but rather the ability to think, learn, plan, be creative and investigate.

"We also hold events for undergraduate students to be role models for them, so that they can see there are women in senior academic positions that also have lives outside of academia."

Theoretical physicist or applied mathematician?

What you are called depends on what country you are in. When I came to the UK the structure was very different to that in Canada. You would be called a physicist in Canada, but over here [UK] you're called an applied mathematician.

I believe there is a continuous scale from maths to physics, and you can sit anywhere on that scale—from pure maths, to experimental physics. So, there doesn't need to be any difference between applied mathematics and theoretical physics.

Can you tell us about your research on the connections between statistical properties of L-functions and RMT?

The Riemann hypothesis—for the Riemann zeta function and other L-functions—says that these functions take value zero at points that lie on a straight line in the complex plane; we call it the *critical line*. These zeros are located at positions along this line—like beads on a wire. The statistical description of how these positions are located is the same for the zeros and for the eigenvalues of suitably defined random matrices (matrices with entries that are random, apart from appropriate symmetry constraints). It turns out that the similarity between the zeros and the eigenvalues is far reaching and means that properties of random matrices can be used to predict properties of the L-functions—even properties that don't seem immediately connected to the positions of the zeros.

So, for example, properties of the values of the Riemann zeta function on the critical line, where it hops along between the zero values, can also be predicted by random matrix theory. Some problems of this sort are extremely hard to solve in number theory, so doing an easier random matrix calculation and having it provide a conjecture for what's happening in number theory is invaluable.

What surprises you about your research?

Given that we are using this rather tenuous, unproven connection between random matrix theory and number theory, what surprises me the most is how our predictions can be so incredibly detailed and accurate!

Why do you believe women are underrepresented in maths?

I'm sure there are many reasons. I think academia demands quite a lot of one. Of course it has its rewards too, but I think it is still the case that to do that top-notch research you have to put a lot of extra time into your job. I've heard female colleagues say that an academic career isn't so important to them that they would sacrifice other parts of their life.

Interview with Nina Snaith—*Continued*

There is also the issue of few role models and still some unconscious bias amongst current academics.

I started a "Women in Maths Group" at Bristol about 12 years ago to support women studying maths. We get together once a week and have lunch, talk about things that are going on I our research and non-research lives. We also hold events for undergraduate students to be role models for them, so that they can see there are women in senior academic positions that also have lives outside of academia.

How important are female role models to girls interested in maths?

Very important. I remember vividly when one of my physics lecturers happened to mention that she had to run because she was picking up her son from football. My friend and I looked at each other with excitement because it was evidence that you could live a regular life, with kids, etc. and be a physicist. So many of our other lecturers were older men, and it was harder to imagine ourselves like them. I'm sure the same is true in maths.

Did anyone else in your family study mathematics?

My dad is an academic mathematician, my grandfather and mother were maths teachers, and my brother has a PhD in maths. I guess that is no coincidence.

Your brother is also a famous musician; do you see a similarity between studying mathematics and music?

The honest answer is that I do not know if there is a link between maths and music. Especially by the time you are performing music professionally. But, I think there is a similarity in the way we learn both of these things.

I observe my son doing his maths homework and I watch him at his piano lessons and I see exactly the same interest in the two activities. With the piano, he's not interested in the tune or making a nice noise (he's 7!)—the bit that captures his interest is the structure. He asks about the length of notes, bars, rests. Clearly it's pattern and structure that interests him, and it's the same with his mathematics. Perhaps there is necessarily more of that in music than in other art forms, which is why music is often linked with maths?

"Now when I want to learn something new I do lots of reading and I am learning about a method in order to solve a specific problem. It isn't a matter of repeating calculations a million times like we have to in school, but rather learning about the area deeply enough to be able to tackle that particular, complicated problem."

As a young student you found mathematics a little dull, but you enjoyed the maths puzzles your father gave you to solve; what do you think the difference was?

We were encouraged to investigate, think about and solve the puzzles ourselves, rather than being "taught", I'm sure that was part of it. Also, there's a lot of repetition involved with gaining facility with maths, as it is taught in school. Sometimes detracts from the excitement of learning something new.

Now when I want to learn something new I do lots of reading and I am learning about a method in order to solve a specific problem. It isn't a matter of repeating calculations a million times like we have to in school, but rather learning about the area deeply enough to be able to tackle that particular, complicated problem. Learning new mathematics as a confident mathematician can be a lot more interesting than the way maths is often taught in school. We have to be creative with the maths and figure out how to apply it.

Can your research be applied to practical applications?

Random matrix theory can be applied to many fields, from communication networks to aerospace engineering, but I was drawn away from the more practical applications to "applying" random matrix theory in pure maths. It's a bit backwards—usually pure maths eventually finds applications in something more concrete but here it's the other way around. A technique that originated in nuclear physics is predicting results in one of the most fundamental areas of pure mathematics: the theory of numbers.

I do my research because there are mathematical questions out there. And these questions are worth answering. I believe that 50 to 100 years from now, the maths we are developing now people will find uses for. But frankly, it's unlikely to be me!

Your work deals quite closely with the Riemann hypothesis, regarded as the most important unproven proposition in mathematics, do you have hope that it will be proven in your lifetime?

It's so hard to say. I don't see signs that it's about to crack any time soon, but with so many fantastic young mathematicians…who can say!

What has your research revealed about the Riemann hypothesis or the Riemann zeta function?

Lots about the Riemann zeta function, such as how fast the function grows on average between its zeros as you move along the critical line, but not much about the Riemann hypothesis!

There has been considerable excitement about the connections between the Riemann Hypothesis and quantum mechanics. Do you know why RMT methods work in calculating the moments of the Riemann zeta function?

It's actually a mystery! It's part of the fun of this area of research. Of course you can observe, and partially prove, the similarity between the two situations and you can use this to shed light on questions in number theory, but fundamentally why this similarity exists…I don't know!

Have these connections been used to suggest any answers to other long-standing and important problems relating to the zeta function?

The question of moments of the Riemann zeta function—that is, average values of the height of the function on the critical line—has been attacked by number theorists for 100 years, and no general answer has been forthcoming. This is clearly an immensely hard problem. Random matrix theory can predict the general answer.

You visited to Australia to give the Hanna Neumann lecture at the AustMS and ANZIAM conference. What will you be presenting?

I give a plenary lecture, much of it was devoted to the history of how random matrix theory and number theory came together, the people involved and the success this partnership has had. There are some pretty fun and interesting stories concerning those who have made contributions to the field. The talk led into the most exciting question at the moment: can random matrix theory shed light on the distribution of ranks of elliptic curves.

And have you had any success with the connection to elliptic curves?

Two of my past PhD students have been working on this project and we are in the middle of it, but we have done enough to have hope that something exciting might happen!

2.3 AMSI-CARMA Lecturer 2015

8–22 May 2015, Professor Jeremy Avigad, Carnegie Mellon University

As well as changing the way we do mathematics, computers are introducing new research agendas. Computational methods in mathematics, including symbolic and numerical computation and simulation, are by now familiar. This lecture series explored the way that "formal methods," based on formal languages and logic, also contribute to mathematics.

In the 19th century, George Boole argued that if we take mathematics to be the science of calculation, then symbolic logic should be viewed as a branch of mathematics. Just as number theory and analysis provide means to calculate with numbers, logic provides means to calculate with propositions. Computers are, indeed, good at calculating with propositions, and there are at least two ways that this can be mathematically useful: first, in the discovery of new proofs, and, second, in verifying the correctness of existing ones.

The first goal generally falls under the ambit of "automated theorem proving" and the second falls under the ambit of "interactive theorem proving." There is no sharp distinction between these two fields, however, and the line between them is becoming increasingly blurry. In his lectures, Professor Avigad provided an overview of both fields and their interactions and speculated on their roles in mainstream mathematics.

Professor Avigad made the lectures accessible to a broad audience, with the first lecture providing a self-contained overview and the remaining sessions for the most part independent of one another and not reliant on the first lecture.

Biography

Jeremy Avigad is a Professor of Philosophy and Mathematical Sciences at Carnegie Mellon University. His research interests include mathematical logic, proof theory, philosophy of mathematics, formal verification, automated reasoning, and the history of mathematics. After receiving a BA in Mathematics from Harvard College in 1989, he completed a PhD in Mathematics at the University of California, Berkeley, in 1995. He has held visiting positions at the Microsoft Research—Inria Joint Centre in France and at Microsoft Research Redmond. He has also held fellowships from the Andrew W. Mellon Foundation and the John Templeton Foundation, and his research has been supported by the National Science Foundation and Air Force Office of Scientific Research.

Lecture 1: Formal Methods in Mathematics

8 May 2015, The University of Newcastle & the ACE network

In this lecture, Professor Avigad provided a general overview of automated and interactive theorem proving. He characterised the general projects and existing technology, and described some recent landmarks and successes in these fields. These included the verification of the Feit-Thompson theorem, the verification of the Kepler conjecture, the use of computers to establish results in algebraic topology, and the recent use of fast satisfiability solvers in connection with the Erdő s discrepancy conjecture.

Lecture 2: Automated Theorem Proving

8 May 2015, The University of Newcastle & the ACE network

In this lecture, Professor Avigad explored automated methods in more detail, describing propositional theorem provers, first-order theorem provers, fast satisfiability methods, and the *satisfiability modulo theories* framework.

Lecture 3: Interactive Theorem Proving

15 May 2015, The University of Newcastle & the ACE network

As well as describing the theory and technology behind contemporary proof assistants, Professor Avigad also discussed logical frameworks, proof languages, and the interaction with automated methods.

Lecture 4: Formal Methods in Analysis

22 May 2015, The University of Newcastle & the ACE network

In his final session, Professor Avigad focused specifically on the use of formal methods in analysis. He discussed linear arithmetic, methods for real closed fields, and methods of handling more general nonlinear expressions, and explained how conventional numeric and symbolic approaches are integrated with formal methods.

Research Training 3

3.0 Research Training—Overview

AMSI's national research training infrastructure sets the gold standard for discipline-wide higher degrees by research (HDR) graduate training in Australia. Established in 2003, our training schools, graduate courses and scholarships prepare STEM graduates to engage in cross-disciplinary research and drive innovation within the public and private sectors. AMSI is currently contributing to the Australian government's review of existing national research training systems and the development of a strategy to reposition Australia as a STEM nation.

Research Training Events

The annual AMSI vacation schools and scholarships programs are funded jointly by the Department of Education and Training and the Australian Mathematical Sciences Institute.

Australian Government
Department of Education and Training

"STEM disciplines are the building blocks for future technologies and the ideas that will improve Australian lives and the country's prosperity."

Professor Geoff Prince, AMSI Director

3.1 AMSI Winter School on Contemporary Aspects of Cryptography

7–18 July 2014, The University of Queensland

A partnership with the University of Queensland, AMSI Winter School features a cutting-edge research program led by international field experts. Aimed at postgraduate students and postdoctoral fellows in the mathematical sciences and related disciplines, the courses aim to expand research knowledge and skills and expose participants to new areas of research.

An international mathematical sciences event, the 9th annual AMSI Winter School explored contemporary aspects of cryptography. Students gathered at the University of Queensland for a two-week series of mini-courses, introductory lectures (leading into current research problems) and specialist lectures. Highlights of this year's social program were the public lecture and the women in mathematics evening.

"Excellent balance of theory and applications. Good mix of lecturers for pros and cons of various applications."

AMSI Winter School 2014 participant

Introductory Courses

Provable Security of Cryptographic Primitives and Protocols

Dr Douglas Stebila, Queensland University of Technology

An introduction to the reductionist security paradigm, also known as provable security using examples of security definitions and proofs for symmetric and asymmetric cryptographic primitives such as hashing, encryption and authentication. The course examined various proof techniques with a focus on game hopping and investigated the difference between the random oracle model and the standard model, explaining the difference between asymptotic and concrete analysis. It concluded with security models and proofs for cryptographic protocols, focusing on key exchange and secure channels.

The Human Side to Cryptography

Associate Professor Benjamin Burton, Queensland University of Technology

Modern cryptography has become extremely powerful through its reliance on deep and extremely interesting mathematics. However, there is a human element that must never be forgotten: even the strongest mathematical scheme can be undone through poor protocols or a weak human link. From World War II through to modern electronic commerce, the course took students on a tour through some remarkable ways in which mathematics, human ingenuity and human error have collided to produce interesting results.

Finite Fields

Dr Joanne Hall, Queensland University of Technology

Many of the advances in communications technologies have been underpinned by properties of algebraic structures. Finite fields are a structure with many applications in digital communications, including systems for cryptography, error correction, data compression and transmission. The course introduced finite fields, explored some of their properties, and gave a taste of their uses in digital communication.

Applications of Coding and Information Theory to Cryptography

Associate Professor Serdar Boztas, RMIT University

Mathematical cryptography and coding and information theory have developed concurrently over the last 65 years, frequently impacting on each other. The course gave a brief telescopic introduction to information and coding theory, discussing their impact on cryptography. Topics covered included: randomness, uniformity and distinguishability; the use of coding theory in designing Boolean functions with cryptographic applications; Code-based cryptosystems which are secure against quantum computation based attacks; the use of Renyi entropies in characterising security of cryptographic schemes against brute force attacks; the use of uniformly chosen random functions to characterise ideal hash functions and their resistance to attacks.

New Mathematical Problems Arising from Cryptographic Research

Dr Alexei Miasnokov, Stevens institute of Technology

New types of mathematical problems related to cryptography require new, more practical types of algorithmic thinking. In algebra, there are many problems for which there is no all-encompassing algorithm—i.e. it is impossible to write a program that will solve all instances of the problem. The course explained that the impossibility of finding a total algorithm does not preclude the possibility of finding an effective algorithm. Showing that an algorithm can often be developed that proves to be useful for most instances of a problem, and the occasions in which the problem cannot be solved are rare. In fact a total algorithmic solution for some problems can be very slow, meaning that it is often more useful to implement fast algorithms that work for most instances.

Advanced courses

Quantum Cryptography

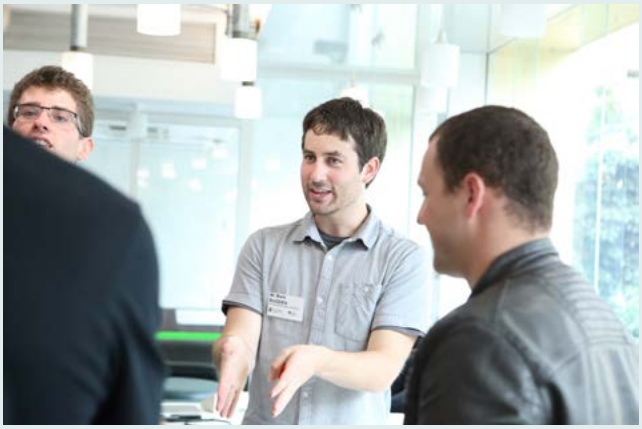
Dr Alessandro Fedrizzi, The University of Queensland
The course focused on some new and exciting mathematical problems that appeared in recent cryptographic research. The main topics included: non-commutative cryptography and algebra, generic and average complexity, non-computable finite sets and Dehn monsters, Challenger-Solver games and hard cores.

Curves and Discrete Logarithms

Professor Tanja Lange, Technische Universiteit Eindhoven
This course considered how to bridge the gaps between algebraic geometry, theoretical cryptography, and real-world information protection. Topics covered included public-key cryptography and the Discrete-Logarithm Problem, Signatures and DLP, curves with endomorphisms and DLPs in intervals and pairings, index calculus and hyperelliptic curves.

"The two weeks were completely amazing. I met a lot of interesting people and feel that I got a lot out of the lectures."

Winter School 2014 participant



"[The AMSI Winter School] got me interested in many more branches of math. I would like to go learn a lot more by myself now."

AMSI Winter School 2014 participant

Other Sponsors

Department of Education and Training, The University of Queensland, Biarri, QCIF

DST Group Short Course: Cryptography in Practice

The Cryptomathematics of Bitcoin

Dr Brett Witty, DST Group
Bitcoin is an enduring hot topic in the tech and finance community. It's the most popular cryptocurrency in the world and involves some interesting uses of modern cryptography. The lecture examined the Bitcoin protocol from the ground-up, and showed how it works from a cryptographic and mathematical perspective.

Techniques in Cryptographic Implementation

Dr Zoltán Bácskai, DST Group
The practical implementation of cryptography is as important as the theory of cryptography. The lecture looked at the intersection and neighbourhood of these ideas, exploring fast methods to do integer and elliptic curve arithmetic for cryptography, the impact of modern hardware on practical cryptography, and how this comes full-circle to potential security issues and ways to mitigate that.

3.2 AMSI BioInfoSummer 2014

1–5 December 2014, Monash University

Australia's leading bioinformatics and mathematical and computational biology training event, AMSI BioInfoSummer has been running since 2003. A core AMSI educational and outreach program, the event is aimed at undergraduate and postgraduate students, researchers and professionals to foster Australia's informatics and computational biology research capability.

Featuring global bioinformatics experts including from Europe and the US, the one-week event explores current research and developments in bioinformatics.

200 researchers and students were inspired and upskilled by an outstanding array of Australian and international speakers, as well as a careers panel, student poster session and software training. An event highlight, Senator Scott Ryan opened the conference with a presentation on the importance of bioinformatics and its underpinning advanced mathematical, statistical and computational techniques.

Other Sponsors

MAXIMA, Monash University, the Department of Education and Training, the Australian Bioinformatics Network, EMBL Australia, Bioplatforms Australia and CSIRO

"BioInfoSummer gave me a great introduction to what the field of bioinformatics provides, and the numerous opportunities that it offers."

Phillip Luong, Monash University

2014 Conference speakers

SPEAKER	ORGANISATION	TALK TITLE
Prof. Kate Smith-Miles	Monash University	A Few Equations That Changed Biology
Monther Alhamdoosh	La Trobe University	Amsi Internship: A Comprehensive Evaluation of Pathway Analysis Tools
Assoc. Prof. Peter Pivonka	The University of Melbourne	Application of Disease Systems Analysis in Osteoporosis
Dr David Lovell	CSIRO	Australian Bioinformatics Network
Dr Keith Schulze Dr Richard Beare	Monash University Monash University	Automating Image Analysis Using Python Scripting
Dr Jonathan Keith	Monash University	Bayesian Methods in Bioinformatics
Dr Daniel Zerbino	EMBL-EBI	Ensembl Regulation: Surveying the Markers of Cell Differentiation Across the Data Matrix
Dr Chris Overall	University of British Columbia	Forward Perspectives in Bioinformatics
Dr Nathan Watson-Haigh	ACPFG	From Microarrays to Co-Expression Networks
Prof. Roger Daly	Monash University	Identification of Novel Treatment Strategies for Human Cancers Through Integrative Phosphoproteomics and Kinomics
Assoc. Prof. Sureshkumar Balasubramanian	Monash University	Introduction of Biology to Maths 2
Dr Keith Schulze Dr Richard Beare	Monash University Monash University	Introduction to Image Processing and Quantitative Analysis Using Imagej/Fiji
Dr Barbara Holland	University of Tasmania	Introduction to Model-Based Methods of Phylogenetic Inference
Simon Michnowicz Stuart Archer Steve Androulakis	Monash University Monash University Monash University	Introduction to Python
Prof. Edmund Crampin	The University of Melbourne	Introduction to Systems Biology
Dr Wei Shi	Monash University	Lab: A Bioconductor R Pipeline for the Accurate and Efficient Analysis of RNA-Seq Data
Assoc. Prof. Andrew Lonie Dr Simon Gladman Clare Sloggett	LSCC Monash University LSCC	Lab: The Genomics Virtual Laboratory (Hands-on Computer Lab)
Assoc. Prof. Andrew Lonie Dr Simon Gladman Clare Sloggett	LSCC Monash University LSCC	Lab: The Genomics Virtual Laboratory and What it Can Do For You
Prof. David Page	University of Wisconsin-Madison	Machine Learning From Genomic and Clinical Data
Dr Federico Frascoli	Swinburne University of Technology	Mathematical Biology of Living Cells
Prof. Falk Schreiber	Monash University	Modelling and Visualising Metabolism
Dr Janusz Dutkowski	Data4Cure	Overview of Network Methods in Bioinformatics
Prof. Phoebe Chen	La Trobe University	Pattern Discovery for Biomedical Applications Using Bioinformatics Technologies
Prof. Mark Ragan	Institute for Molecular Bioscience	Phylogenetics Without Multiple Sequence Alignment
Prof. Marc Wilkins	University of New South Wales	Proteomics and Quantative Mass Spectrometry
Dr Annette McGrath	CSIRO	RNA-Seq Differential Expression
Prof. Gordon Smyth	WEHI	RNA-Seq: From Reads to Genes to Pathways
Assoc. Prof. Jean Yee Yang	The University of Sydney	Statistics in Bioinformatics
Dr Tianhai Tian	Monash University	Stochastic Modelling and Simulation of Genetic Regulatory Networks
Dr Alicia Oshlack	Murdoch Childrens Research Institute	Transitioning From Mathematics to Biology: What You Need to Know
Dr Mark Cowley	Garvan Institute	Using Next Generation Sequencing to Uncover Tumour Heterogeneity, Tumour Evolution, and Early Cancer Detection

"I congratulate the Australian Mathematical Sciences Institute on running BioInfoSummer to assist researchers across a range of disciplines to develop key statistical and mathematical skills that will enable them to pursue innovation."

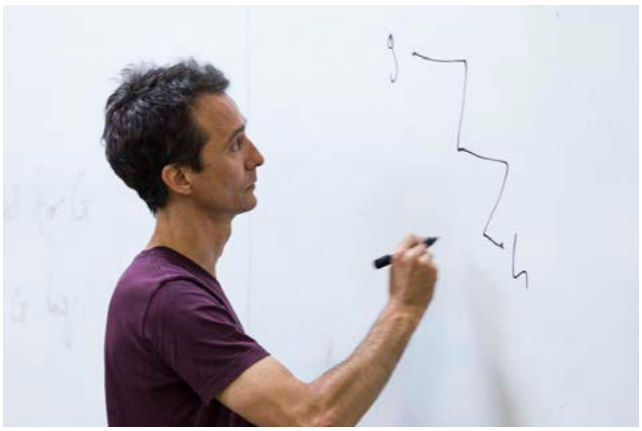
Senator the Hon Scott Ryan, Parliamentary Secretary to the Minister for Education

3.3 AMSI Summer School 2015

5–29 January 2015, The University of Newcastle

Australia's biggest student mathematics event, AMSI Summer School is a four-week residential research training program designed to take students to the cutting-edge of mathematical sciences to enhance discipline knowledge and employability. With a commitment to outstanding education and training, sessions count as course credits with career development and networking opportunities giving students the competitive edge as they pursue their research career.

The 13th annual AMSI Summer School brought 110 honours and postgraduate students from around the country for an intensive four-week residential program. Students had the opportunity to tackle one or two of the eight intensive honours level pure and applied mathematics and statistics subjects on offer. During their time at the residential school, students complemented their academic work with enrichment lectures, social events, a careers afternoon and other special events.



"The AMSI Summer School offers some very niche subjects that most universities can't provide, taught by Australia's best mathematicians and statisticians. I also like how the teachers have all the time in the world for us to consult with them."

Mahrita Harahap, University of Technology Sydney

Courses

Computational Bayesian Statistics

Dr Chris Drovandi, Queensland University of Technology
Dr Gentry White, Queensland University of Technology
As the complexity of statistical models grows to more accurately capture the behaviour of real processes in many scientific fields, so has the need for developing associated computational algorithms so that these models can be calibrated against observed data. This subject introduced students to basic and advanced computational statistics algorithms with the focus on solving problems in Bayesian statistics. In addition, this subject gave students the opportunity to improve their scientific programming skills.

Continued Fractions

Professor Wadim Zudilin, The University of Newcastle
Continued fractions are an aged child of the queen of mathematics, number theory and the king of mathematics, analysis. The summer course served as a semi-classical introduction into the subject with emphasis on the theory of both regular and irregular continued fractions and their applications to metric number theory, diophantine equations and special functions.

Geometric Group Theory

Dr Murray Elder, The University of Newcastle
Dr Lawrence Reeves, The University of Melbourne
Groups and geometry are ubiquitous in mathematics. This course introduced students to the study of infinite groups from the geometrical viewpoint and drew on ideas from low dimensional topology and from hyperbolic geometry. The principal focus was the interaction of geometry/topology and group theory: through group actions and suitable translations of geometric concepts into a group theoretic setting.

Intermediate Probability

Professor Louise Ryan, University of Technology Sydney
Probability theory is the foundation of modern statistical science. This course went beyond introductory concepts to provide students with a sound working knowledge of multivariate distributions, moment generating and characteristic functions, convergence theory and Poisson processes.

Statistical Mechanics

Professor Jan De Gier, The University of Melbourne
Dr Nathan Clisby, The University of Melbourne
Dr Tim Garoni, Monash University
Statistical mechanics is a branch of mathematical physics which studies the emergent behaviour of large collections of interacting particles, using a probabilistic approach. This course focused on discrete models in statistical mechanics, in which the systems are defined on regular lattices. The main interest in these models stems from the fact that they display critical phenomena: macroscopic properties of the models change abruptly as a parameter is varied through a critical value. This course explored both two-dimensional systems, for which very precise results can often be proved, and three-dimensional systems, for which efficient approximation schemes provide the strongest type of solution that can be hoped for.

Introduction to Nonlinear PDEs

Dr Mike Meylan, The University of Newcastle
This course was an introduction to nonlinear partial differential equations, focusing on nonlinear wave phenomena. We considered applications from physics, ocean engineering, chemical engineering, civil engineering and biology. The underlying partial differential equations were derived and the properties of the solutions investigated. Simulations of the PDEs were obtained using MATLAB.

Nonlinear Control Theory

Dr Zhiyong Chen, The University of Newcastle
The core of this course was a systematic and self-contained treatment of the nonlinear control theory for stabilisation and regulation problems. Its coverage embraced both fundamental concepts and advanced research outcomes and included many numerical and practical examples. Several classes of important uncertain nonlinear systems were discussed. The state-of-the-art solution presented uses of robust and adaptive control design ideas in an integrated approach. The course took advantage of rich new results to give students up-to-date instruction in the central design problems of nonlinear control, problems which are a driving force behind the furtherance of modern control theory and its application. The diversity of systems in which stabilisation and regulation become significant concerns in the mathematical formulation of practical control solutions makes the course relevant to students from a wide variety of backgrounds.

Optimisation

Associate Professor Regina Burachik, University of South Australia
To optimise is to search for a best option given the circumstances. The need for doing this is found everywhere from the natural and social sciences to engineering, business and economics. Optimising requires a model, a mathematical theory for solving the model, and a computer code to implement the theory. This course focused on the mathematical aspects of optimisation. The first part of the course gave basic tools of convex analysis, convex functions and separation theorems. We established optimality conditions for several kinds of optimisation problems, including convex (non-differentiable) and differentiable ones. In the second part of the course, we analysed convergence properties of classical optimisation methods, such as steepest descent, Newton, and their variants, for unconstrained problems. Finally, we studied penalty, barrier, and exact penalty methods for constrained problems.

Other sponsors:

The University of Newcastle, Department of Education and Training, AustMS, ANZIAM

"The intellectual content is of a high standard. The networking opportunities and social opportunities are valuable and unique. It is one of the programs that elevates undergraduate mathematics in Australia to an international standard."

Daniel Ogburn, The University of Western Australia

3.4 AMSI Vacation Research Scholarships 2014/15

December 2014–February 2015

Fifty-seven of our brightest undergraduate students gave up lazy summer days at the beach to work on AMSI Vacation Research Scholarship (VRS) projects.

Through this program, AMSI provides monetary scholarships to give students a taste of research life and encourage them to pursue mathematics as a career. Over six weeks, participants experience life as a researcher, working closely with a supervisor and presenting their findings at the AMSI Big Day In student conference. This year several past VRS students were VRS supervisors.

Big Day In

The 2015 Big Day In was opened by AMSI Deputy Director, Professor Gary Froyland. His address was followed by an inspiring lecture by Dr Federico Frascoli, who gave the students some sage advice about pursuing academic careers.

Before the presentations, students were given opportunity to put questions to the well-established academics and industry professional on this year's career panel. On the panel were:
Dr Federico Frascoli, Swinburne University of Technology
Professor Gary Froyland, Deputy Director, AMSI
Michelle Roldan, Crown Resorts
Associate Professor Marcel Jackson, La Trobe University
Tori McFarlin, Biarri
Dr Maria Athanassenas, DST Group

Hosted by AMSI at The University of Melbourne, the conference gave most students their first opportunity to present research in front of academics and their peers.

The presentations were all enthusiastically received with prizes awarded for the best presentations on each day.

2015 Students and projects

Student	Supervisor/s	Project Title
AUSTRALIAN NATIONAL UNIVERSITY		
Omar Ghattas	Dr Dale Robert	Pricing Contingent Claims on Crypotucurrencies
Xun Chun Tee	Prof. Alan Welsh	Model Selections in Linear Mixed Model
DEAKIN UNIVERSITY		
Laura Smith	Dr Simon James	Maintaining Consistency of Individual Preferences During Consensus Rounds in Group Decision Making
GRIFFITH UNIVERSITY		
Bryce Hackett	Assoc. Prof. Peter Johnston	Mathematical Model of Oscillatory Calcium Signals
Marsel Gokovi	Dr Owen Jepps	The Travelling Time Across Microporous Potentials and the Diffusion Coefficient
LA TROBE UNIVERSITY		
Asha Gair	Prof. Brian Davey	Quasi-Primal Cornish Algebras
Kari Matthews	Dr Grant Cairns, Dr Yuri Nikolayevsky	Free Groups Generated by a Pair of Parabolic Matrices
Morgan Hunter	Dr Agus Salim	Linear Mixed Models with Gaussian Mixture to Identify Contaminants in Proteomics Data: A Prelude to Intra-Experiment Normalisation.
Zackary Burton	Dr Yuri Nikolayevsky, Dr Grant Cairns	Geometry of Minkowski Space
MONASH UNIVERSITY		
Angus Southwell	Dr Daniel Mathews, Dr Daniel Horsley	Knots, Cords and Skeins
Benjamin Jones	Dr Norman Do	The Interplay Between Knots and Representations
David Ceddia	Dr Pascal Buenzli	Kinetic Gas Theory of Bone Cell Activation with Moving Surfaces
Gilbert Oppy	Dr Anja Slim, Assoc. Prof. Michael Page	Discrete Dynamics of a Bouncing Ball
Jiemi (Jimmy) Lin	Dr Jennifer Flegg	Modelling the use of Supplemental Oxygen to Combat Surgical Site Infection
Max Jolley	Dr Norman Do	Counting Coverings of the Sphere
Musashi Ayrton Koyama	Dr Daniel Mathews, Dr Daniel Horsley	Programming with Topology

Student	Supervisor/s	Project Title
MONASH UNIVERSITY (*continued*)		
Rahil Valani	Dr Anja Slim, Dr Joel Miller	Wave Particle Duality of Multiple Bouncing Fluid Droplets
Shmuli Bloom	Dr Enrico Carlini	Sums of Power Decompositions
Tyson Liddell	Dr Jerome Droniou	Topological Degrees and Applications
QUEENSLAND UNIVERSITY TECHNOLOGY		
Alex Browning	Prof. Matthew Simpson	Random Walk Models on Growing Domains: Mean Particle Lifetime Analysis
Liam Polkinghorne	Dr Joanne Hall	Nonlinear Codes of Length 4 on 4 Symbols
RMIT UNIVERSITY		
John Tait	Dr Stephen Davis	Ballprint Identification of Infants: Is it Possible?
Mi Do	Dr Stelios Georgiou	Linear Codes over Large Alphabets
Norah Finn	Assoc. Prof. Anthony Bedford, Dr Elsuida Kondo	Workload and Performance—The Development and Application of Predictive Models for the Australian Wheelchair Rugby Team
Rohit Kumar	Assoc. Prof. John Shepherd	Smith's Population Model in a Slowly Varying Environment
Si-Zhong (Simon) Lu	Dr Yan Ding, Sargon Gabriel	Integrating Multiple Time-Scales Involved in Arterial Mass Transport
Stephen Pang	Assoc. Prof. Anthony Bedford, Dr Elsuida Kondo	Modelling Nhl Data—Prediction, Performance and Analysis of Ice Hockey's Big Data
THE UNIVERSITY OF MELBOURNE		
Anas Rahman	Dr Nicholas Witte	Densities and Moments of the Beta Ensembles in Random Matrix Theory
Bohao Yao	Dr Charl Ras, Hamid Mokhtar	Algorithm for Finding Hamiltonian Cycle in Planar Graphs
Campbell Wheeler	Assoc. Prof. Paul Norbury	Mirror Symmetry and Topological Quantum Field Theory
Naijian (Eric) Shen	Prof. John Sader	Vibration of a Thin Rectangular Cantilever Plate in Viscous Fluid
THE UNIVERSITY OF QUEENSLAND		
Hamish Thorburn	Dr Michael Forbes	Mathematical Models for Cricket
Liam Hodgkinson	Prof. Phil Pollett	Understanding the Effect of Individual Variation in Epidemics
Timothy Buttsworth	Dr Artem Pulemotov	Riemannian Metrics on Doubled Manifolds
Trent Skorka	Dr Phillip Isaac	Lie Symmetries of Differential Equations
UNIVERSITY OF ADELAIDE		
John Connell	Prof. Michael Murray	Visualising Complex Functions
Lachlan Bubb	Assoc. Prof. Joshua Ross	A Study of Epidemiological Models, with Particular Focus on Estimation of R0 for Ebola Virus Disease
Parsa Kavkani	Dr Hang Wang	Dirichlet's Theorem of Arithmetic Progressions and Generalisations
UNIVERSITY OF NEW SOUTH WALES		
Christopher Rock	Assoc. Prof. John Murray, Dr Richard Gray	HIV and Periodic Presumptive Treatment of Stis in Papua New Guinea
Terence Harris	Prof. Michael Cowling	Noncommutative Calculus
Tingyu Mao	Assoc. Prof. Ian Doust	Maximal P-Negative Type for Different Norms on R^3
THE UNIVERSITY OF NEWCASTLE		
Thomas Robinson	Assoc. Prof. Murray Elder	1324 Avoiding Permutations
THE UNIVERSITY OF SYDNEY		
Abraham Chi Shun Ng	Assoc. Prof. Daniel Daners	The Dirichlet-to-Neumann Operator
John Peter Wormell	Dr Uri Keich, Prof. John Robinson	A Fast and Numerically Robust Method for Computing Pearson's Exact Multinomial Goodness-of-fit Test
Joshua Ciappara	Dr Oded Yacobi	Spherical Harmonics and Categorical Representation Theory
Kristen Emery	Dr Uri Keich, Prof. John Robinson	Sequential FDR
Nathan Duignan	Prof. Georg Gottwald	Understanding Time Series of Ice-Core Data and Building Models to Reproduce Ice Ages
Nicholas Katada	Dr Ray Kawai	Optimal Convergence Rate of Leave-One-Out Likelihood Estimation for the Location Parameter of Unbounded Densities
THE UNIVERSITY OF WESTERN AUSTRALIA		
Adrian Petersen	Assoc. Prof. Phill Schultz	Unique and Non-Unique Decomposition in Rings
Anahita Haghighat	Prof. Lyle Noakes, Prof. Jingbo Wang	Quantum Algorithms; a Geometrical Perspective
Ben Luo	Dr Thomas Stemler, Prof. Michael Small	Analysis of Irregularly Sampled Time Series
Kyle Rosa	Prof. Lyle Noakes, Prof. Lucho Stoyanov	Inverse Scattering by Finitely Parameterised Planar Obstacles
UNIVERSITY OF WOLLONGONG		
Anthony Flynn	Dr Glen Wheeler, Dr Yann Bernard, Dr Valentina Mira-Wheeler	Wente's Inequality in Higher Dimensions
Lauren Borg	Prof. Brian Cullis, Dr Emi Tanaka	Issues in Qtl Analysis and Association Studies in Plants with High Dimensional Marker Platforms
Nicole Cocks	Prof. Brian Cullis, Dr Emi Tanaka	Statistical Protocols for Late Maturity Alpha-Amylase in Wheat
WESTERN SYDNEY UNIVERSITY		
Hind Abdallah	Dr Laurence Park, Assoc. Prof. Glenn Stone	Aggregating and Sampling Rankings

VRS - Summary of Research

Wave Particle Duality in Multiple Bouncing Fluid Droplets

Scholar: **Rahil Valani**, Monash University
Supervisors: **Dr Anja Slim & Dr Joel Miller**, Monash University

USING OUR ANALYSIS WE WERE ABLE TO FIND STATIONARY STATES, parallel walking states and orbiting states for two droplets, as well as stationary states for three droplets which were confirmed numerically and also found experimentally. By investigating the dynamics of three droplets, various trajectories and exotic orbits were identified. The model that was studied in this paper is quite simplified and limited as the trajectory equation only takes in account the interaction due to the previously generated wave. A new model was developed in 2013 [1] which takes into account the interaction of all the previously generated waves and therefore the trajectory equation includes a memory parameter. This memory parameter plays a vital role near the regime where these bouncing droplets are known to exhibit certain quantum mechanical phenomenon. So one way to extend this project would be to look into the stability and the dynamics of two and three droplets using the new model.

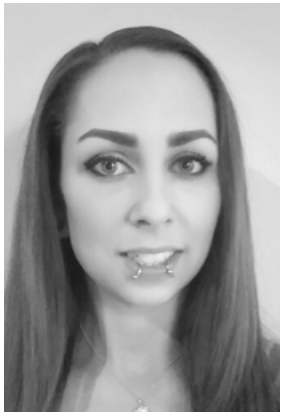
[1] J. Molacek and W. Bush Drops walking on a vibrating bath: towards a hydrodynamics pilot-wave theory. Journal of Fluid Mechanics, 727, 612–647, 2013.

Understanding the Effect of Individual Variation in Epidemics

Scholar: **Liam Hodgkinson**, The University of Queensland
Supervisor: **Professor Philip Pollett**, The University of Queensland

AUSTRALIA DEVOTES CONSIDERABLE RESOURCES TO PROGRAMS DESIGNED TO PROTECT ITS biodiversity and to limit the spread of disease. For example, the Australian National Health and Medical Research Council (NHMRC) provided $700 million in funding for epidemiological research between 2002–2013 [1]. However, these programs can only be effective if the dynamics of the populations in question are well understood. An empirical study was conducted by Lloyd-Smith et al. in 2005 [2] to determine the effect of individual variation in conjunction with Galton-Watson branching processes. The authors concluded that "emerging disease outbreaks cannot be fully understood if individual variation in infectiousness is neglected" [ibid.]. The primary reason for this is the natural emergence of so-called 'super-spreaders' which infect a significantly larger number of people than the average individual. This has become increasingly apparent since Dr Liu Jianlun spread the SARS virus to over 16 other guests on the same floor of a Hong Kong hotel he was staying at; which is believed to have triggered the 2003 global outbreak of the disease [3]. The goal of this project was to introduce individual variation in infectiveness into a more advanced, well-established model in ecology introduced by Hanski in 1994 [4], and apply it in the field of epidemic modelling, with some emphasis on implementing the model in practice and reproducing the conclusions [5].

[1] National Health and Medical Research Council. NHMRC research funding datasets based on burden of disease and health issues, 2013.
[2] J. O. Lloyd-Smith, S. J. Schreiber, P. E. Kopp, and W. M. Getz. Superspreading and the effect of individual variation on disease emergence. Nature, 438:355–359, 2005.
[3] World Health Organisation. How SARS changed the world in less than six months. Bulletin of the World Health Organisation, 2003.
[4] Ilkka Hanski. A practical model of metapopulation dynamics. Journal of Animal Ecology, 63:151–162, 1994
[5] A. D. Barbour and Peter Hall. On the rate of Poisson convergence. Mathematical Proceedings of the Cambridge Philosophical Society, 95:473–480, 1984.



Quasi-primal Cornish algebras

Scholar: **Asha Gair**, La Trobe University
Supervisor: **Professor Brian Davey,** La Trobe University

A CORNISH ALGEBRA IS A BOUNDED DISTRIBUTIVE LATTICE equipped with a family of unary operations each of which is either an endomorphism or a dual endomorphism of the bounded lattice. They are a natural generalisation of Ockham algebras, which have been extensively studied. Recently, Davey, Nguyen and Pitkethly characterised quasi-primal Ockham algebras. We given a external characterisation of quasi-primal Cornish algebras and derive from it a completely internal sufficient condition for a Cornish algebra to be quasi-primal. Our results yield the Davey–Nguyen–Pitkethly result for Ockham algebras as a special case. Both the necessary-and-sufficient condition and the sufficient condition are expressed in terms of the Priestley dual of the algebra. All results presented here are new. This report is the initial draft of a research paper to be submitted to Studia Logica.

Pricing Contingent Claims on Cryptocurrencies

Scholar: **Omar Ghattas**, Australian National University
Supervisor: **Dr Dale Roberts**, Australian National University

CRYPTOCURRENCIES, SUCH AS BITCOIN, HAVE RECENTLY EMERGED AS ALTERNATIVES TO fiat money for those seeking low transaction costs, anonymity and protection from the loose monetary policy of central banks. The growth of these new currencies can potentially be hindered by their high price volatility, negating the store of value characteristic that is desirable in any established currency. This will undoubtedly lead to the arrival of derivative securities (aka. contingent claims), in which these currencies are the underlying assets, in an attempt to manage that risk.

The traditional Black-Scholes option pricing approach, which revolutionised the role of mathematics in finance, has an obvious shortcoming when employed to pricing options on assets such as Bitcoins. The failure of the model is arguably a direct product of the related assumptions that there is an endless supply of the asset and the market is perfectly liquid (i.e. buying and selling does not change the market price). These assumptions are violated in the case of cryptocurrencies. First, coins are issued into circulation through the process of mining. They are rewarded to miners as an incentive for solving increasingly difficult and computationally intensive proof-of-work mathematical problems. The difficulty of these problems is directly related to the speed at which they are mined, which in turn affects the supply of coins. Second, as coins are in limited supply, the action of buying and selling (a necessary step in replicating and hedging a contingent claim) can drastically affect the market price of the asset.

The aim of this project was to investigate the pricing of contingent claims on cryptocurrencies such as Bitcoin. We approached this task by first attempting to model volatility of Bitcoin prices by making use of the novel and growing concept of noncausal time series models that would be able to capture the speculative price bubbles evident in the price. We applied the methodology outlined by Hencic and Gourieroux [1] to a larger data set spanning from 01/04/2014–20/01/2015. The final model fit was a MAR(2, 1). The next steps of this project are to be able to make predictions of the Bitcoin price based on our model as well as connect the pricing of Bitcoin to the pricing of contingent claims on Bitcoin.

[1] Hencic, A., Gouriroux, C. (2015). Noncausal Autoregressive Model in Application to Bitcoin/USD *Exchange Rates*. Econometrics of Risk (pp. 17–40). Springer International Publishing.

3.5 ACE Honours Courses

The standard undergraduate degree program is a three-year bachelor course followed by an honours year, including a research thesis. Every year, the AMSI member institutions run mathematical Honours year subjects in the Advanced Collaborative Environment (ACE Network) enabling students from several universities at once to participate in Honours subjects remotely.

Theory of Statistics

July-October, 2014, La Trobe University
Associate Professor Paul Kabaila
Synopsis: Aimed at fourth year students, this subject covers a selection of topics in classical statistical inference.
Number of participants: 13

Topology and Dynamics

July-October, 2014, La Trobe University
Dr John Banks
Synopsis: Students developed and applied definitions and results of very general application to explore the theory of (discrete time) topological dynamics. This included an exploration of chaos and related dynamical properties.
Number of participants: 8

Analysis

July-October, 2014, Macquarie University
Professor Xuan Duong
Synopsis: An advanced analysis course, students closely followed the first five chapters of the textbook *Real and Complex Analysis* by Walter Rudin.
Number of participants: 5

Complex Networks

July-October, 2014, RMIT University
Dr Stephen Davis
Synopsis: Focusing on recent advances over the last two decades this course examined our understanding of the structure of complex networks. With an emphasis on the analytical techniques used to classify and characterise networks, students were asked to analyse real networks themselves.
Number of participants: 13

Mathematical Biology: A Nonlinear Dynamics Approach

July-October, 2014, RMIT University
Professor Lewi Stone
Synopsis: This course surveyed exciting concepts in mathematical biology that have arisen over the past few decades with an emphasis on nonlinear dynamical systems approaches with applied bifurcation theory.
Number of participants: approx. 11

Topological Groups

July-October, 2014, The University of Newcastle/University of Wollongong
Professor Jacqui Ramagge and Professor George Willis
Synopsis: An introduction to the theory of topological, and in particular locally compact groups, this course explained and, in special cases, proved fundamental theorems.
Number of participants: 11

Experimental Mathematics

July-October, 2014, The University of Newcastle
Laureate Professor Jon Borwein
Synopsis: Experimental Mathematics uses a computer to run computations—sometimes no more than trial-and-error tests—to look for patterns, and identify particular numbers and sequences. This is used to gather evidence in support of specific mathematical assertions that may themselves arise by computational means, including search.
Number of participants: 7

Integrable Systems

July-October, 2014, The University of Sydney
Dr Sarah Lobb and Dr Milena Radnovic
Synopsis: In this course, students studied the mathematical properties of both continuous and discrete integrable systems. Participants saw partial differential and difference equations and their relations; constructed soliton solutions; performed symmetry reductions to the Painlevé equations; and identified various aspects of integrability.
Number of participants: 3 remote students (number of local students unrecorded)

Advanced Topics in Fluid Dynamics

July-October, 2014, The University of Sydney
Dr Geoffrey Vasil
Synopsis: This course provided an introduction to a classic set of fluid instabilities that drive a wide range of observable phenomena in astrophysics, the geosciences, and engineering. Students studied the dynamics of: (i) Rayleigh-Benard thermal convection, (ii) centrifugally unstable Taylor-Couette flow, (iii) shear-driven Kelvin-Helmholtz vortices, (iv), and transition to turbulence.
Number of participants: 2 remote students (number of local students unrecorded)

Advanced Collaborative Environment (ACE) Network

In 2015, AMSI launched the Advanced Collaborative Environment (ACE) Network. Replacing the Access Grid Room (AGR) Network, ACE has strengthened engagement within the Australian and international, mathematical sciences communities. The new, sophisticated Visimeet software has improved functionality and reliability of the remote teaching and research collaboration network. The full program of ACE events resumed from mid-2015.

"Students being able to watch the lecture at home seems to be popular and working well. This should be promoted."

ACE Honours course participant

Analysis

March-May, 2015, Macquarie University
Professor Xuan Duong
Synopsis: An advanced analysis course, students closely followed the first five chapters of the textbook *Real and Complex Analysis* by Walter Rudin.
Number of participants: 6

Introduction to Nonlinear PDE

March-May, 2015, The University of Newcastle
Dr Michael Meylan
Synopsis: An introduction to nonlinear partial differential equations, focusing on nonlinear wave phenomena, this course considered applications from physics, ocean engineering, chemical engineering, civil engineering and biology.
Number of participants: 8

Partial Differential Equations in Mathematical Biology

March-May, 2015, The University of Sydney
Dr Peter Kim
Synopsis: The course focused on partial differential equation (PDE) models in mathematical biology. PDE models capture a wide range of biological phenomena, including spatial and age-structured interactions.
Number of participants: 11

Statistical Consulting

March-May, 2015, University of Wollongong
Professor Ray Chambers
Synopsis: In this subject we considered issues associated with the role of statistical consultant and client. Topics included: communication skills, choosing analysis techniques, developing appropriate study designs, questionnaire development and piloting, researching the unknown, sample size, initial interviews, follow-up interviews, analysing data, reporting, and time management.
Number of participants: unrecorded

Advanced Data Analysis

March-May, 2015, University of Wollongong
Dr Pavel Krivitsky
Synopsis: This course introduced students to a variety of techniques for advanced data analysis, particularly regression, for handling categorical data, dependent data, nonlinear data, and situations where parts of the model are unknown or misspecified. Generalised linear models were considered in detail, as well as other ways of modelling nonlinearity, such as nonlinear models and nonparametric analysis.
Number of participants: 5

Fractional Calculus

March-May 2015, University of Wollongong
Dr Marianito Rodrigo
Synopsis: This course covered the basics of fractional calculus, or more aptly called the calculus of derivatives and integrals to an arbitrary order. Starting with a historical survey, students were encouraged to consider some special functions that are frequently used in this field.
Number of participants: unrecorded

"I think the sharing of Honours subjects through AMSI is great! It really helps us provide a diversity of options for our students. It works surprisingly well."

ACE Honours course participant

3.6 Early Career Workshop

The Australian Mathematical Society Conference, 6–7 December 2014

The sixth Annual Early Career Workshop ran on the day preceding the annual Australian Mathematical Society Conference (AustMS), giving early career researchers the opportunity to meet before the conference.

The theme for the 2014 workshop was the first five years post-PhD, focusing on career advice for early career researchers in the mathematical sciences.

Throughout the day workshop participants received advice from a broad range of topic experts who provided insights from the secrets behind grant success, to how to effectively manage time between teaching, research and administrative commitments. Question and answer sessions provided plenty of opportunity for participants to interact with the speakers.

The afternoon included an informal networking session which gave participants the opportunity to meet other early career researchers, share their experiences and build professional networks.

"The information presented was useful for my career."

Workshop participant

Organisers

Dr Norman Do, Monash University
Professor Andrew Francis, Western Sydney University
Dr Roslyn Hickson, The University of Newcastle and IBM Research, Australia

Special presenters

Associate Professor Benjamin Burton, The University of Queensland
Dr Adelle Howse, Leighton Holdings
Professor Geoff Prince, AMSI
Professor Ole Warnaar, The University of Queensland
Dr María Angélica Cueto, Columbia University
Dr Mark Flegg, Monash University
Dr David Harvey, University of New South Wales

Program structure

The workshop consisted of three research presentations, four advice sessions, two Q&A sessions, and an informal icebreaker/networking session.

Web Links

www.austms2014.ms.unimelb.edu.au/early-career-workshop/

Other Sponsors

AustMS and the NZMS

Contact

Dr Norman Do, Monash University
norm.do@monash.edu

3.7 Australian Mathematical Sciences Student Conference

The University of Newcastle, 2–4 July 2014

Today's postgraduate students ultimately become tomorrow's research leaders. With this in mind, early opportunities to network are critical to the progression of students' careers. However, the great distance between Australian universities makes it difficult for many to meet and exchange ideas.

The Australian Mathematical Sciences Student Conference (AMSSC) provides postgraduate students from across the country with the opportunity to showcase their work, facilitate dialogue, and explore future collaborations. In addition it provides students with the opportunity to gain conference experience.

The AMSSC complements the AMSI summer and winter schools. Focusing on postgraduate coursework it provides an opportunity for the same target group of students to present their own research—for many attendees this will be their first chance to do so.
The 2014 AMSSC provided crucial opportunities for Australian postgraduate students and brings us on par with other countries around the world. It will establish deeper links between various universities and departments at the student level and help lift Australia's research profile by providing a facility for mutual exchange and collaboration.

Organisers

Christopher Banks, The University of Newcastle
Novi Bong, The University of Newcastle
Rachel Bunder, The University of Newcastle
Cameron Rogers, The University of Newcastle
Michael Rose, The University of Newcastle
Matthew Tam, The University of Newcastle

Special presenters

Dr Michael Coons, The University of Newcastle
Research interests: number theory
Dr Vera Roshchina, Federation University Australia
Research interests: real complexity, theoretical optimisation and dynamical systems
Associate Professor Matthew Simpson, Queensland University of Technology
Research interests: cell biology, computational modelling, mathematical modelling, multiscale modelling and random walks
Professor Brian Alspach, The University of Newcastle
Research interests: discrete mathematics and graph theory

Web Links

http://amssc.org/2014/

Other Sponsors

AustMS, CARMA, The University of Newcastle

Contact

Christopher Banks, The University of Newcastle
amssc2014@newcastle.edu.au

3.8 Heidelberg Laureate Forum

The Heidelberg Laureate Forum is an annual meeting, which provides highly talented young researchers with the opportunity to engage with the winners of the most prestigious scientific awards in Mathematics (Abel Prize, Fields Medal and Nevanlinna Prize) and Computer Science (ACM Turing Award). This provides an outstanding platform for scientific dialogue across generations.

Each year AMSI and AustMS provide funding to support young Australian researchers attendance at the event.

2015 recipients

Philipp Bader, La Trobe University
Melissa Lee, The University of Western Australia
Matthew Tam, The University of Newcastle
Anna Tomskova, University of New South Wales
John Tsartsaflis, La Trobe University

Matthew Tam, Ioannis Tsartsais and Melissa Lee share their experience

In August 2015, 200 young researchers from around the globe gathered in picturesque Heidelberg for the 3rd Heidelberg Laureate Forum (HLF).

The 3rd Heidelberg Laureate Forum (HLF) was held in Heidelberg's picturesque old city from 23–28 August 2015. Supported by the Klaus-Tschira-Stiftung, since 2013, the Forum has brought young researchers from around the globe together with laureates.

This year approximately 200 young researchers, inducing five young Australian mathematicians, engaged in cross-generational dialogue with 26 laureates including Leonard Adleman (ACM Turning Award recipient and co-inventor of the RSA cryptosystem), Shigefumi Mori (Fields Medalist and president of the International Mathematical Union), and Vinton Gray Cerf (ACM Turning Award recipient and co-inventor of the TCP/IP protocols). The group of young researchers included five young mathematicians working in Australia.

The students were honoured have the opportunity to meet with the laureates, and put a face and a personality to their famous names. Many found it humbling that, when asked how they decided which problems and areas to work on, many of the laureates simply replied "I just do what I find interesting."

With a full program of activities, there was plenty of time for the young researchers and laureates to get better acquainted. Each day of the academic program began with a number of engaging talks from the laureates

The afternoon sessions included short workshops run by the more senior young researchers, stimulating "hot topic" discussions, and visits to local institutions including the German Cancer Research Centre and the Max Planck Institute for Mathematics.

Highlights of the social program included dinner in a museum aside a Russian space shuttle in the nearby town of Speyer, a Bavarian Night with a little Schuhplattler (Bavarian dance) just for good measure, and, no visit to Heidelberg would be complete without the renaissance ruins of the spectacular Heidelberg Castle.

The Heidelberg Laureate Forum was a fantastic opportunity to engage with, learn from, and be inspired by mathematicians and computer scientists who have achieved remarkable things and reached the top of their respective fields, as well as to network with an international cohort of up and coming young researchers.

Industry Research Program 4

4.1 AMSI Intern

AMSI Intern works at the interface between academia and industry, creating and strengthening links between businesses and universities to increase awareness of the value-add that can be achieved through the engagement of high-level research capability.

Covering a range of disciplines, the program delivers Australia's young and brilliant minds to industry to enhance the postgraduate experience, as well as provide students with the opportunity to apply their research skills within an industry context. This in turn provides a platform for industry to engage and attract talent into their organisation through short-term tightly focused research projects.

AMSI Intern is Australia's leading PhD internship program having placed over 120 postgraduate students into industry.

In 2015, AMSI Intern established a strategic partnership between eight AMSI member universities to expand the program in Victoria and New South Wales. The partnership will deliver the federal government's current agenda on the commercialisation of publicly funded research with every internship strengthening collaboration between academia and industry—ensuring a work-ready PhD student and a significant outcome for the industry partner.

This program provides a crucial boost to business and university partnerships. Australia currently ranks 29 out of 30 countries in the OECD for business-university collaboration—a stark contrast to its ranking as ninth in research output per capita amongst OECD nations.

1 Australian Technology Network of Universities (ATN) PwC Report 'Innovate and Prosper—Ensuring Australia's Future Competitiveness through University-Industry Collaboration,' March 2015.

"Australia must strengthen industry pathways for high-level research graduates to foster greater business-university collaboration and innovation. Importantly, to build industry confidence we need to ensure graduates have the skills and confidence to work outside of the academic environment."

Professor Geoff Prince, AMSI Director

Success stories

Engineering on a roll: How smart wireless devices can help keep toilets stocked and clean

TO CONSTANTLY CHECK CUBICLES CAN come at a significant cost to business, not to mention the waste involved in replacing almost-empty soap containers and toilet rolls to avoid the trouble of patrons finding them bare. How can cleaning companies keep the soap, hand towels and toilet tissues stocked efficiently, with minimum wastage?

AMSI Intern worked with KCrown to enable the company to develop prototype products in collaboration with Deakin University. PhD students Vikram Nadar and Jennifer Lewis used a combination of mathematics and engineering to find a smarter way to clean up.

During the initial stages of the project, Vikram worked to design and build an electronic wireless system to manage stock levels. The prototype is able to sense the current level of stock and transmit the data to a web server. Once the electronics were operational, it was time for Jennifer to begin customising the software, implementing mesh networking.

Associate Professor Abbas Kouzani, who supervised both the KCrown internships, remarked that reliable low-power wireless communication solutions are difficult to realise. "It has been extremely beneficial for both the students and the industry partner to be able to engage with one another through AMSI Intern and complete several stages of the one large project," says Abbas.

Financial investments a modeller's minefield

BUDGETING, IT'S A CRINGE WORTHY word. Optimisation, that sounds more like it! But have you the faintest idea of what it is? And did you know that mathematicians use it to help financial planners increase the expected size of their client's financial nest egg with risks acceptable to them and their stage in life?

AMSI Intern student, Wei Wu, is well versed in the use of the mathematical technique of optimisation in finance. In fact, he recently completed an internship at Optimo Financial—an Australian company that services the financial planning sector.

With over 25 years experience applying optimisation techniques to build energy and financial models, Hugh Bannister, Principal, Optimo Financial, believes Wu's work during his recent internship will allow Optimo to improve its offerings to the market.

"Optimo's existing tools greatly improve financial planners ability to offer good, robust financial advice to clients, Wei Wu's input and work strengthens these tools," Bannister says.

Wu, a PhD candidate at the University of New South Wales, is sure the internship will be beneficial to his future career. The most valuable experience, he says, was seeing the differences between theoretical modelling and real world circumstances.

"People have different investment needs, some invest for the short-term, saving for a house deposit, or long term, saving for their retirement. I was able to apply my mathematical skills to help financial planners find the best investment strategies for their clients by looking at, and taking into account, numerous factors," Wu says.

"Optimo had developed a conceptual approach to solving this problem, but sought academic input through AMSI Intern to ensure the state-of-the-art in the field was recognised," Bannister says.

"The academic mentors and Wei Wu were able to make certain the proposed approach was theoretically and practically sound and were also able to explore possible improvements."

More success stories can be found at: http://amsiintern.org.au/success-stories/

4.2 Mathematics in Industry Study Group (MiSG)

Queensland University of Technology, 27–31 January, 2015

AMSI delivers the annual Mathematics in Industry Study Group in partnership with ANZIAM. Applied mathematicians, statisticians, physical scientists and engineers apply cutting-edge mathematical science to provide practical working solutions to real life problems facing industry and business within Australia and New Zealand. Industry partners range from multinationals to smaller business leaders.

The MiSG provides business with access to high-calibre professionals, tools and technologies to improve capacity and capability in problem solving and decision making. Each year, 100 world-leading applied mathematicians, statisticians and physical scientists attend, using the opportunity to apply their skills to business participant challenges.

The MiSG 2015 industry projects delivered a range of challenges for mathematical statistics, operational mathematics, applied and computational mathematics researchers.

"Congratulations on the MiSG week. I was truly impressed with the outcome your group achieved. The result will be a much improved door design that requires less electricity to keep a house comfortable and uses less resources to manufacture. Awesome!!"

Nigel Spork, CEO Centor Designs Pty Ltd

Projects

Structural Modelling of Deformable Screens for Large Door Openings
This project aimed to develop mathematical models of the deformation of Centor's Integrated Doors (porous and deformable) screens and shades under various wind loadings.
Partner: Centor

Management of Stock Levels for the Manufacture of Aortic Stents
Using demand forecasting, this project aimed to predict the stock levels of raw materials required to manufacture various aortic stent grafts to ensure that demand is met at a predefined level of service.
Partner: Cook Medical

Optimal Reserves Allocation
This project optimised the placement of relays to meet given physical requirements at minimal cost.
Partner: Transpower

Modelling the Effects of Property Addressing Uncertainty
As well as modelling errors in the CRCSI geospatial dataset, this project aimed to quantify their impact on various users.
Partner: CRCSI, Queensland Government

Pressure Drop in Pipelines due to Pump Trip Event
To increase design engineers' confidence in the surge protection allowed at the early stages of design, this project drove a high-level "formula" for estimating the magnitude of the deceleration pressure drop at a pump station.
Partner: Sun Water

Modelling the Probable Maximum Precipitation for Large Catchments
This project assessed current methodology and investigated alternative approaches to determining the probability of extreme catchment rainfall events.
Partner: Sun Water

MiSG receives acclaim from industry partners as a low cost, high yield investment in problem solving. Some partners have implemented MiSG practices directly following the workshops, while others have expanded their investment into collaborative research partnerships to solve even larger business challenges.

Every MiSG industry partner receives a brief summary report immediately following the MiSG workshop. These reports capture the essence of what was achieved during the workshop and summarise the ongoing work to be discussed in full technical detail in a final report.

"Again thanks to the group this year. The learnings for us are invaluable."

Wayne Dale, Principal Analyst Queensland Department of Transport and Main Roads

Special presenters

Professor Thomas Witelski, Duke University
Research interests: perturbation methods, asymptotics and numerical approaches to study applied questions in fluid dynamics, nonlinear partial differential equations and dynamical systems
Professor Peter Coaldrake, Vice-Chancellor and CEO, Queensland University of Technology
Research interests: public sector management and higher education policy and management

Web Links

http://mathsinindustry.com/about/misg-2015/

Other Sponsors

ANZIAM, Queensland University of Technology

Contact

Associate Professor Troy Farrell, Queensland University of Technology
t.farrell@qut.edu.au

4.3 Parks Victoria Partnership

Protecting Australia's iconic flora and fauna sustained with statistics

AMSI provides statistical support to Parks Victoria's environmental monitoring, evaluation and reporting processes through a partnership program established in 2010.

Kally Yuen, AMSI Statistician

An accredited statistician, Kally is an experienced biostatistician, having worked at the Peter MacCallum Cancer Centre and Centre for Youth Mental Health at The University of Melbourne.
Accredited by the Statistical Society of Australia in 2004, Kally's qualifications include a Master of Science degree in Statistics, Bachelor of Science degree with First Class Honours in Statistics and Computer Science. She received the Maurice Belz First Prize for Statistics while she was an undergraduate at The University of Melbourne.

Kally specialises in survival analysis, generalised linear models and relational database management systems. She is experienced in statistical consulting, research study design, study protocol and research database development, statistical analyses of research data, protocol review for research and ethics committees and grant assessment. Highly published, she has been a co-author in more than 30 research publications, 14 as a senior author. She has nurtured new talent as an instructor in statistics training courses and supervisor for research students.

Projects

Weed Monitoring in the Dandenong Ranges
A series of weed surveys were conducted over several years to assess the effectiveness of the program. Kally analysed and reported on the data with Dr Marie Keatley, Environmental Scientist (Flora). Their results have assisted regional staff to guide weed management and have been used to support an application for further funding from the Urban Fringe Weed Management Initiative (UFWMI). Kym Saunders, UFWMI Officer, Yarra Ranges Council, presented the findings at the 19th Australasian Weeds Conference.

Experimental Weed Management in the Alpine National Park
Stage 2 of the English Broom adaptive experimental management program commenced in November 2013. Comparing a range of different ways to control the English Broom weed, the project evaluated the effectiveness of different methods. The information collected has been used for the continual improvement of weed management approaches and to determine which herbicides are most effective and how to use them most efficiently. Dr Marie Keatley and Kally Yuen designed the second stage of the program and updated the progress of the initiative at a workshop for land managers. Charlie Pascoe, Alps Landscape Program Manager for Environment, Land and Water, presented these results at the 19th Australasian Weeds Conference.

Remote Camera Monitoring
In response to management activities, Parks Victoria deploys remote cameras in a wide range of parks and habitats to provide information on native fauna. Since 2012, Kally has been involved in monitoring programs at Great Otways National Park and Warrandyte State Park. This year, Kally Yuen and Dr Mark Antos, Environmental Scientist (Fauna) co-wrote a chapter for the CSIRO publication: *Camera Trapping Wildlife Management and Research*.

Overabundant Koala Management
Over-browsing by koalas inhabiting French Island has significantly impacted local vegetation. Consequently, the koala population is considered too large to be sustained by the habitat. RMIT University student Harmeet Kaur and her supervisor, Professor John Hearne, were selected from a list of AMSI Intern applicants to work on the development of a framework to guide decision-making and implementing management actions on French Island. Lorraine Ludewigs, Environmental Scientist, and Kally assisted in the intern selection process and provided feedback on Harmeet's final report.

ACRONYMS

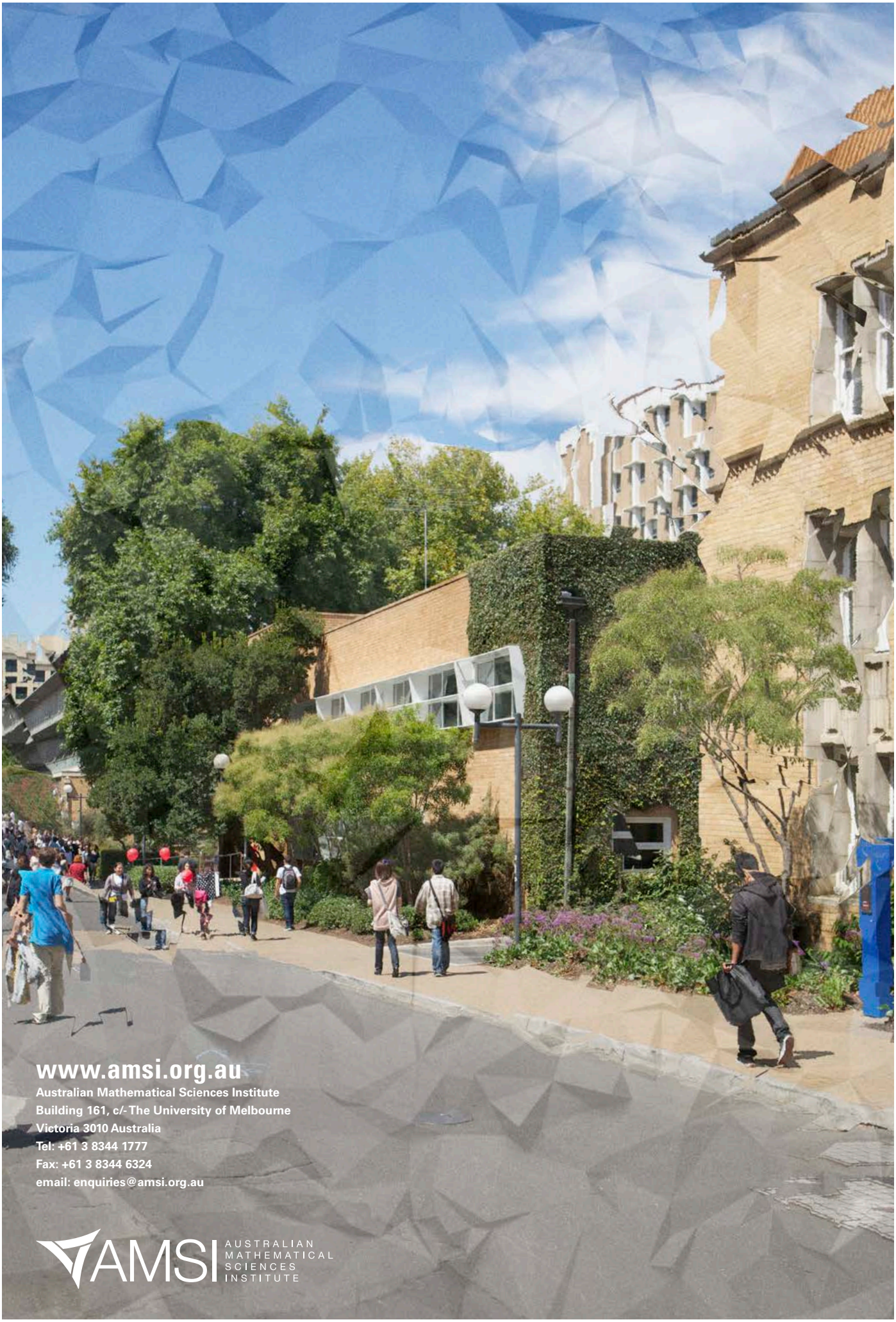
ABS	Australian Bureau of Statistics
ACEMS	ARC Centre of Excellence for Mathematical and Statistical Frontiers
ACPFG	Australian Centre For Plant Functional Genomics
ADFA	The Australian Defence Force Academy
AMSI	Australian Mathematical Sciences Institute
AMSSC	Australian Mathematical Sciences Student Conference
AMT	Australian Mathematics Trust
ANU	The Australian National University
ANZIAM	Australian and New Zealand Industrial and Applied Mathematics
ARC	Australian Research Council
AustMS	Australian Mathematical Society
BOM	Bureau of Meteorology
CARMA	The Priority Research Centre in Computer Assisted Mathematics and Applications, The University of Newcastle
CIAM	Centre for Industrial and Applied Mathematics at the University of South Australia
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DST Group	Defence Science Technology Group
ECR	Early Career Researchers
EMBL-EBI	European Molecular Biology Laboratory-European Bioinformatics Institute
FAAAS	Fellow to the Australian Academy of Science
FAustMS	Fellow of the Australian Mathematical Society
FedUni	Federation University Australia
FRSC	Fellow of the Royal Society of Canada
HDR	Higher Degrees by Research
HLF	Heidelberg Laureate Forum
IMPA	Instituto Nacional de Mathemática Pura e Applicada
ISI	The Institute for Scientific Information
ITMS	School of Information Technology and Mathematical Sciences at the University of South Australia
JCU	James Cook University
LSCC	The VLSCI Life Science Computation Centre
MathSciNet	Mathematical Reviews Database, maintained by the American Mathematical Society
MAXIMA	The Monash Academy for Cross and Interdisciplinary Mathematical Applications
MiSG	Mathematics in Industry Study Group
MSI	Mathematical Sciences Institute, Australian National University
MSRI	Mathematical Sciences Research Institute, Berkeley, CA, USA
NHMRC	Australian National Health and Medical Research Council
NZMS	New Zealand Mathematical Society
OECD	Organisation for Economic Co-operation and Development
QCIF	The Queensland Cyber Infrastructure Foundation
QUT	Queensland University of Technology
RSA	Rivest-Shamir-Adleman
SPCM	South Pacific Conferences in Mathematics
UCLA	University of California, Los Angeles
UFWMI	Urban Fringe Weed Management Initiative
UNE	The University of New England
UniSA	University of South Australia
UNSW	University of New South Wales
UoM	The University of Melbourne
UoN	The University of Newcastle
UOW	University of Wollongong
UQ	The University of Queensland
USQ	University of Southern Queensland
USYD	The University of Sydney
UTas	University of Tasmania
UTS	University of Technology Sydney
UWA	The University of Western Australia
UWS	Western Sydney University
VLSCI	Victorian Life Sciences Computation Initiative
VRS	Vacation Research Scholarships
VU	Victoria University
WEHI	The Walter and Eliza Hall Institute of Medical Research

Editorial team: *Laura Watson, Simi Henderson, Liam Williamson, Mari Ericksen, Stephanie Pradier and Jo Wilson. Design and layout by Michael Shaw.*

Our Mission

The radical improvement of mathematical sciences capacity and capability in the Australian community through:

- the support of high quality mathematics education for all young Australians
- improving the supply of mathematically well-prepared students entering tertiary education by direct involvement with schools
- the support of mathematical sciences research and its applications including cross-disciplinary areas and public and private sectors
- the enhancement of the undergraduate and postgraduate experience of students in the mathematical sciences and related disciplines



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