AMSI
SUMMER SCHOOL 18
IN THE MATHEMATICAL SCIENCES

8 JAN – 2 FEB 2018 MONASH UNIVERSITY, CLAYTON

EVENT REPORT

AMSI AUSTRALIAN MATHEMATICAL SCIENCES INSTITUTE

MONASH University

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AMSI Summer School 2018

in the Mathematical Sciences

Monash University

8 January to 2 February 2018


AMSI
NATIONAL

FOREWORD

The AMSI Summer School is one of five premier flagship events hosted each year around Australia and forms part of the Securing Australia's Mathematical Workforce: 2016-2020 agreement between AMSI and the Department of Education and Training. Now in its 15th year, this key program has become of the most important calendar events for honours and postgraduate students in the mathematical sciences and cognate disciplines.

Hosted over four weeks, this program offers eight distinct subjects and gives students the opportunity to learn from highly experienced lecturers from all around Australia.

The complete program, comprising course content and extra activities, is designed to align with the project objectives of the agreement to:

- Strengthen research training and the work-readiness of advanced mathematical sciences graduates;
- Promote university-industry collaborations that will encourage the private sector employment of mathematical sciences graduates;
- Attract and improve the retention of senior undergraduate students in the mathematical sciences, with particular attention to women and Aboriginal and Torres Strait Islanders.

AMSI Summer School 2018 was jointly funded by the Australian Mathematical Sciences Institute (AMSI) and the Australian Government's Department of Education and Training, with support from Monash University, Australian Mathematical Society (AustMS), Australian New Zealand Industrial and Applied Mathematics (ANZIAM), Statistical Society of Australia (SSA), the Australian Signals Directorate, Monash Centre for Quantitative Finance, Commonwealth Bank and the BHP Billiton Foundation through the Choose Maths program.

DIRECTOR'S REPORT

The AMSI Summer School is one of the premier events on the mathematical calendar for both advanced students and academics in Australia. It enables Honours students, postgraduate students and early-career researchers to come together over four weeks, take advanced courses, meet and socialise with their contemporaries and be exposed to mathematical sciences beyond the confines of their institutions. This is especially beneficial for students from smaller institutions. For academics, it is an opportunity to lecture and interact with the brightest students from around Australia.

Each year the Summer School grows larger, and for the 2018 Summer School at Monash University the attendance matched the 2017 Summer School record with 168 registrations, with 61 attendees enrolling in the topic on Statistical Machine Learning. As well as being a focus for domestic students, the Summer School is strongly supported by international students studying in Australia, with 59 international registrations this year. The feedback from international students is that this is a unique opportunity in their studies. This year we also welcomed one student who travelled from Europe. Support to attend the Summer School was provided to 46 students through Travel Scholarships and 16 students through Choose Maths Scholarships.

One of the highlights this year was the engagement of the students, which gave the normally dormant Maths Building an infectious buzz for all of January. Much of the credit must go the lecturers for their appealing and approachable presentations of advanced mathematics and statistics. Special mention is to be made of Tiangang Cui and Ivan Guo for stepping in at the eleventh hour to run a successful topic on Statistical Machine Learning.

The lectures and support classes for all the topics, which were presented in a variety of formats, were well attended throughout the four weeks, with 82 students sitting the final exam for a topic for credit and one student sitting an exam for interest.

The focal point every day at the Summer School was morning tea where students, lecturers and staff from Monash University were able to meet and chat. Lunch was also lively with a weekly BBQ and LunchMaths lecture. The morning teas and lunches were made possible through the support of Monash University's School of Mathematical Sciences. The excursions beyond Melbourne on the first two weekends were a particular highlight of the social activities.

Finally, I would like to thank the sponsors, without whom this event would not be possible, and the many people who worked tirelessly in the year-long planning and execution of the Summer School. The Program Standing Committee gave significant thought in choosing a broad range of topics and lecturers, which were relevant, appealing and would complement the programs at students' home institutions. The record registrations and student engagement attests to the quality of this program. In the latter part of 2018 the Organising Committee swelled to involve at least six people working almost full-time on the preparation of the Summer School. Particular thanks go to Anna Haley and Gertrude Nayak from Monash University, and Geoff Prince, Chloe Pearse and Anna Muscara from AMSI.

COURSE PROGRAM

The academic program consisted of eight courses throughout the intensive four-week timetable. Students were given the opportunity to enrol in up to two courses, and had the option to take one course for credit, completing assessment tasks including a final examination, and obtaining a passing grade.

Courses offered could be roughly categorised as follows:

Iterative methods for sparse matrices
Associate Professor Timothy Moroney, Queensland University of Technology

Low-dimensional topology *(Sponsored by AustMS)*
Dr Daniel Mathews, Monash University
Associate Professor Jessica Purcell, Monash University

Mathematical relativity and Lorentzian geometry
Dr Andy Hammerlindl, Monash University
Associate Professor Todd Oliynyk, Monash University

Mathematics of extensional flows *(Sponsored by ANZIAM)*
Professor Yvonne Stokes, The University of Adelaide

Probabilistic methods and random graphs
Professor Nick Wormald, Monash University
Dr Jane Gao, Monash University

Probability, complex analysis and lattice models
Dr Laurie Field, The Australian National University
Dr Gregory Markowsky, Monash University

Statistical machine learning *(Sponsored by SSA)*
Dr Ivan Guo, Monash University
Dr Tiangang Cui, Monash University

Topological data analysis
Dr Vanessa Robins, The Australian National University
Dr Katharine Turner, The Australian National University

The summer school was a fantastic opportunity. I had the chance to study so many courses I wouldn't have access to at my home university, and in most cases the lecturers went out of their way to make high-level material accessible with a minimal background. The range of courses was great - I don't think anyone felt they didn't have anything to do. I also really appreciated getting to see more of the range of what's in topology. It's such a broad field, and the two topology courses did a great job of giving us a taste of what's out there.

Adele Jackson, Australian National University

Iterative methods for sparse matrices

Associate Professor Timothy Moroney, Queensland University of Technology

Synopsis: Sparse matrices arise in many applications across science, engineering, statistics, business and beyond. Exploiting the sparsity of these matrices is essential for overcoming the scaling on storage and floating-point calculations that otherwise renders even problems with dimensions in the thousands utterly impractical to solve.

A remarkably versatile family of numerical methods called Krylov subspace methods can be applied to sparse matrix operations, and in doing so requires only having minimal requirements on the means by which a matrix is utilised, paving the way for many of today's high-performance codes. This course covered Krylov subspace methods for three common problems: linear systems, eigenvalue problems and matrix functions, from their derivation through to efficient numerical implementation.

Content:

- Arnoldi iteration
- Theory of Arnoldi iteration
- GMRES
- Preconditioning
- Restarting and deflation
- Jacobian free Newton-Krylov methods
- Matrix functions

Number of students who completed the course:	**14**
Number of students who passed the course for credit:	**7**
Feedback: agreed the course was of a high standard:	**100%**

Low-dimensional topology

Dr Daniel Mathews and Associate Professor Jessica Purcell, Monash University

Synopsis: The study of spaces of dimensions 2, 3, and 4, including the study of surfaces and their symmetries, knots and links, and structures on 3- and 4-manifolds, is an area of active research with deep connections to mathematical fields such as geometry and dynamics and modern applications to microbiology, chemistry and quantum physics. It requires a different set of tools to higher-dimensional topology. This course covered some foundational results of low-dimensional topology, studying surfaces in two dimensions, knots in three dimensions, and some applications in four dimensions.

Content:

- Surfaces and their homeomorphisms
- The mapping class group and Dehn twists
- 3-manifolds: Heegaard splittings and Dehn filling
- Decompositions of 3-manifolds
- Knots and knot invariants

Number of students who completed the course:	**32**
Number of students who passed the course for credit:	**19**
Feedback: agreed the course was of a high standard:	**92.3%**

Sponsored by The Australian Mathematical Society

Mathematical relativity and Lorentzian geometry

Dr Andy Hammerlindl and Associate Professor Todd Oliynyk, Monash University

Synopsis: General Relativity is currently our most accurate theory of gravity. It applies across a huge range of physical scales describing the motion of small bodies such as satellites orbiting Earth to the dynamics of supermassive black holes and even our universe. General relativity is formulated in the language of differential geometry. This course introduced the differential geometry needed to understand the fundamental concepts and field equations of general relativity. Applications of the theory to static black holes, the perihelion precession of Mercury's orbit and gravitational waves were discussed.

Content:

- Manifolds, manifolds with boundary, smooth maps, submanifolds, partitions of unity
- Tangent vectors and spaces, tangent bundles, tangent maps, vector bundles, vector fields
- Multilinear algebra, tensors, tensor bundle, tensor fields
- Contractions, index manipulation, tensor derivations, Lie derivative
- Metrics, covariant derivatives, Curvature
- Fundamental concepts of Mathematical Relativity
- Einstein Field equations
- Schwarzschild solution
- Applications: perihelion precession of Mercury's orbit, linearized Einstein equations and gravitational waves

Number of students who completed the course:	**29**
Number of students who passed the course for credit:	**9**
Feedback: agreed the course was of a high standard:	**95%**

Mathematics of extensional flows

Professor Yvonne Stokes, The University of Adelaide

Synopsis: This course focused on extensional flows having a small geometric parameter or aspect ratio. These are ubiquitous in nature and industry and include honey dripping from a spoon, ink-jet printing, the float-glass process used for making sheet glass, and a spider spinning a web. We considered the work on the so-called 'Trouton viscosity' modelling of the spinning of polymer threads in the late 60s and early 70s, through to modern research particularly relating to the fabrication of optical fibres.

Content:

- Trouton models and the Trouton viscosity
- Scaling and asymptotic methods
- The Reynolds transport theorem and the equations of Newtonian fluid flow
- 1D model derivation, neglecting inertia and surface tension
- Lagrangian coordinate systems
- Finite-time 'blowup'
- Drop 'pinch-off'
- Draw stability
- Inclusion of surface tension and the cross-plane problem
- The 'reduced-time' transformation
- Extension of a solid rod
- Extension of an axisymmetric tube

Number of students who completed the course:	**14**
Number of students who passed the course for credit:	**7**
Feedback: agreed the course was of a high standard:	**70%**

Sponsored by Australian and New Zealand Industrial and Applied Mathematics

Probability, complex analysis and lattice models

Dr Laurie Field, Australian National University and Dr Gregory Markowsky, Monash University

Synopsis: Physicists have long conjectured that many of their discrete models in the plane have conformally invariant scaling limits at criticality. Recent work by mathematicians has shown this to be correct, as well as identifying the natural limiting process of interfaces in many of these models as the Schramm–Loewner Evolution (SLE). This theory has led to the rigorous determination of critical exponents such as the Brownian intersection exponents and the Hausdorff dimensions of many random planar fractals.

In the first half of this course, we studied the most important discrete models that exhibit conformal invariance in the scaling limit, and discussed which forms of discrete complex analysis can be used to illuminate these models.

In the second half of the course, we passed to the continuum, where Brownian motion becomes a key tool. By applying Loewner's differential equation to a Brownian motion on the boundary, we obtained the definition of SLE, derived its first important properties, and heuristically explained why it is the scaling limit of interfaces in the models studied in the first half. In addition, a fair amount of necessary complex analysis was developed along the way, with planar Brownian motion being employed as a key tool.

Content:

- Simple random walk and its convergence to Brownian motion
- Loop-erased random walk and the uniform spanning tree
- Critical percolation and Smirnov's proof of conformal invariance
- The Ising model and its discrete holomorphic fermions
- Self-avoiding walk and the connective constant on the hexagonal lattice
- Lévy's Theorem on the conformal invariance of Brownian motion
- Analytic functions and conformal maps
- The Poisson Integral Formula and its relation to Brownian motion
- (Non-random) Loewner Evolution
- The basics of the Schramm–Loewner Evolution and its relation to the discrete physical processes

Number of students who completed the course:	**14**
Number of students who passed the course for credit:	**5**
Feedback: agreed the course was of a high standard:	**63%**

Probabilistic methods and random graphs

Professor Nick Wormald and Dr Jane Gao, Monash University

Synopsis: The probabilistic method proves the existence of a mathematical structure by showing a random element in an appropriate probability space has the desired properties with positive probability. This course introduced some basic techniques of the probabilistic method and applications in graph theory and combinatorics. In particular, the probabilistic method gives easy proofs of the existence of some graphs (and other objects) that are very hard to construct explicitly, or not known to exist by other methods. The course also studied random graphs: graphs selected at random from some given probability space, proving some appealing properties of these graphs and demonstrating how they can be incorporated into the probabilistic method.

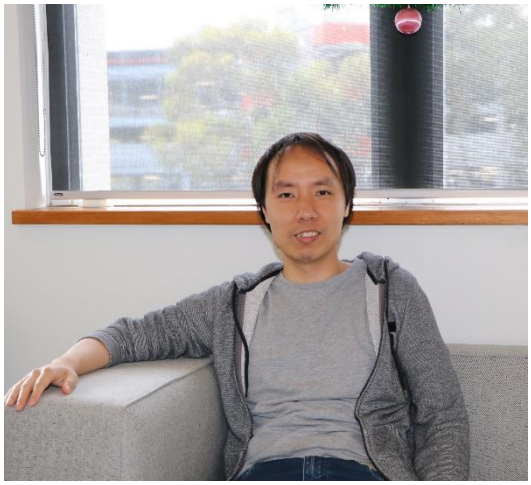
Content:

- Linearity of expectation and alterations
- The second moment method
- Random graph models and properties
- The local lemma
- Martingales and concentration inequalities
- Janson's inequality
- Randomised algorithms and de-randomisation

Number of students who completed the course:	**24**
Number of students who passed the course for credit:	**4**
Feedback: agreed the course was of a high standard:	**93%**

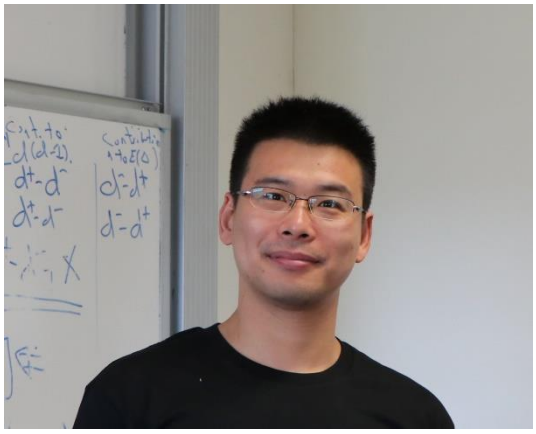
Statistical machine learning

Dr Ivan Guo and Dr Tiangang Cui, Monash University



Synopsis: Statistical machine learning merges statistics with the computational sciences—computer science, systems science and optimisation. Much of the work in statistical machine learning is driven by applied problems in science and technology, where data streams are increasingly large-scale, dynamic and heterogeneous, and where mathematical and algorithmic creativity is required to bring statistical methodology to bear. The applications include financial modelling, pattern recognition and remote sensing. In this course we studied how to use probability models to analyse data, focusing on the mathematical details of the models and the algorithms for computing them.

Content:



- Bayesian inference and parameter estimation
- Regression and classification
- Sampling methods
- Time series filtering

Number of students who completed the course:	**46**
Number of students who passed the course for credit:	**28**
Feedback: agreed the course was of a high standard:	**74%**

Sponsored by the Statistical Society of Australia

Statistical Society of Australia

Topological data analysis

Dr Vanessa Robins and Dr Katharine Turner, The Australian National University

Synopsis: Topological Data Analysis (TDA) is an interdisciplinary field combining methods from algebraic topology, statistics and computational algorithms. It quantifies the shape of data over a full range of length scales and, most importantly, captures how that shape changes as the length scale parameter is varied. Its diverse applications include the quantification of bone morphology and porous materials, the connectivity structure of the brain, and time series analysis.

This course covered the relevant background from algebraic topology, to provide a detailed overview of persistent homology (the main tool in TDA) and various approaches to summarising the information provided by persistent homology. Since any data analysis must consider the effect of randomness and of noise we also studied statistical aspects in TDA including stability, correlation and statistical significance tests.

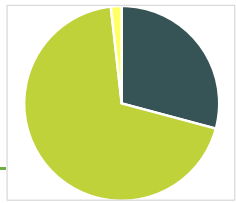
Content:

- Introduction to homology
- Filtrations and persistent homology
- Essential algorithms in TDA
- Summaries of persistent homology information
- Statistical aspects of TDA
- Further techniques: Discrete Morse theory, the Reeb graph and Mapper
- Example applications

Number of students who completed the course:	**21**
Number of students who passed the course for credit:	**3**
Feedback: agreed the course was of a high standard:	**94%**

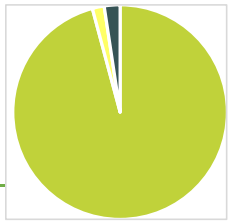
PARTICIPATION STATISTICS

Enrolments by Institution	
Australian National University	13
Charles Sturt University	1
Deakin University	3
Delft University of Technology	1
Flinders University	1
La Trobe University	2
Macquarie University	1
Monash University	63
Murdoch University	1
RMIT University	2
The University of Adelaide	12
The University of Melbourne	30
The University of New England	1
The University of New South Wales	10
The University of Newcastle	4
The University of Queensland	9
The University of Sydney	4
The University of Western Australia	3
University of Southern Queensland	2
University of Technology Sydney	1
University of Wollongong	3
Other	1
TOTAL	168



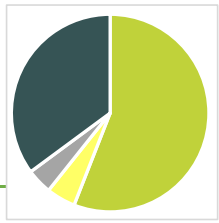
GENDER

Male	116	69%
Female	49	29%
Prefer not to disclose	3	2%



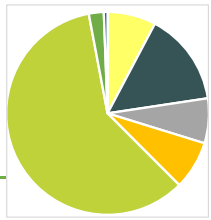
ATSI STATUS

Yes	3	2%
No	161	96%
Prefer not to disclose	4	2%



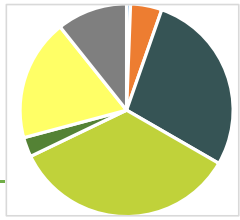
RESIDENCY STATUS

Australian Citizen	94	56%
Permanent Resident	7	4%
Student Visa	59	35%
Other	8	5%



STATE/TERRITORY

ACT	13	8%
NSW	25	15%
QLD	12	7%
SA	13	8%
VIC	100	59%
WA	4	2%
TAS	0	0%
INTERNATIONAL	1	1%



ACADEMIC STATUS

Undergraduate	18	11%
Honours	47	28%
Masters	58	35%
PhD	31	18%
Early-Career Researcher	8	5%
Other	5	3%

GRANTS

AMSI Travel Grants

AMSI Travel Grants are offered to support AMSI Member students attending flagship higher-education events by funding their travel and accommodation. AMSI Summer School 2018 grants were funded by AMSI, Monash University and the Australian Government's Department of Education and Training, and were determined on a competitive basis. In 2018, AMSI Travel Grants were awarded to 46 students from 12 AMSI Member Universities:

- Mahdi Abolghasemi, The University of Newcastle
- Seamus Albion, The University of Queensland
- Dickson Yaw Badu Annor, The University of Sydney
- Pouya Baniasadi, Flinders University
- David Brook, The University of Adelaide
- Ryan Brown, The University of Adelaide
- Adam Chan, The University of Sydney
- Nelson Chen, The University of New South Wales
- Huy Chung, The University of New South Wales
- Zachary Dowton, The Australian National University
- Al Malik Dzulkipli, The University of Adelaide
- Andrei Ermakov, University of Southern Queensland
- Joseph Fyfield, The University of Queensland
- Anthony Gallo, The University of Adelaide
- Andrew Grose, Murdoch University
- Adam Hamilton, The University of Adelaide
- Edward Holloway, The University of Queensland
- Daniel Hutchings, The University of Western Australia
- Declan Jamieson, The University of Adelaide
- Nurul Yakim Kazal, The Australian National University
- James King, The Australian National University
- Wanwan Kurniawan, The Australian National University
- David Lee, The University of New South Wales
- Colin MacLaurin, The University of Queensland
- Adam Mammoliti, The University of New South Wales
- Sahar Masoudian, The Australian National University
- Lachlann McArthur, The University of Adelaide
- Nicholas McLean, The University of Adelaide
- Jan Mölter, The University of Queensland
- Thomas Murray, The University of Newcastle
- Kenyon Ng, The University of Western Australia
- Tui Nolan, University of Technology Sydney
- Anthony Parr, The University of Queensland
- Joseph Peach, The University of New South Wales

- Shiqiu Qiu, The Australian National University
- David Quarel, The Australian National University
- Matthew Ryan, The University of Adelaide
- Michael Sandford, The University of Adelaide
- Jordan Shaw-Carmody, The University of Newcastle
- Ankit Shrestha, University of Wollongong
- Albert Christian Soewongsono, The Australian National University
- Andrew Tasker, The University of Adelaide
- Ryan Turner, The University of Western Australia
- Likun Yao, Australian National University
- Marley Young, The University of New South Wales
- Dewei Zhuang, The University of Queensland

Choose Maths Grants

Choose Maths Grants are designed to offer full and partial support for Australian female mathematical sciences students and early-career researchers to participate in the AMSI higher-education programs and/or assist with caring responsibilities. The BHP Billiton Foundation, as an initiative of the Choose Maths program, funded these grants to help women build and extend their mathematical skills and professional networks. In 2018, Choose Maths Grants were awarded to 16 female students from 10 AMSI Member Universities:

- Kimberly Becker, The University of Adelaide
- Laura Cartwright, University of Wollongong
- Samten Choden, The Australian National University
- Youstina Elzahaby, The University of New South Wales
- Xiangyuanchai Guo, The University of Sydney
- Elizabeth Harris, The University of Newcastle
- Yuting Huang, The Australian National University
- Adele Jackson, The Australian National University
- Madeleine Kyng, The University of New South Wales
- Cassie Marshall, The University of Queensland
- Elizabeth McCarthy, University of Southern Queensland
- Ellena Moskovsky, Monash University
- Theresa O'Brien, University of Wollongong
- Shuaige Qiao, The Australian National University
- Hanyi Yang, The University of Sydney
- Liya Zhao, The University of Queensland

I enjoyed the chance to travel to and experience life at a different university, as well as be able to learn about two topics in which I am very interested. I loved meeting so many new people, and I am grateful for all the new networks I have built for myself.

Laura Cartwright, University of Wollongong

EVENT HIGHLIGHTS

Opening Ceremony

The Summer School was officially opened by Dr Charles Day (CEO, Office of Innovation and Science Australia). Also speaking at the Opening Ceremony were Professor Marc Parlange (Provost, Monash University), Professor Jordan Nash (Dean of the Faculty of Science, Monash University), AMSI Director Professor Geoff Prince, and Gertrude Nayak, (School of Mathematical Sciences, Monash University). The ceremony was attended by approximately 168 students, the Summer School lecturers, and members of the Monash University School of Mathematical Sciences. This was followed by morning tea, a group photograph and tours of the campus.

Diversity in STEM Event

The Diversity in STEM discussion was a lunchtime session hosted by Professor Ian Wanless, School of Mathematical Sciences. The discussion commenced with a talk by Dr Zuleyka Zevallos (most recently Program Manager of Science Australia Gender Equity) on barriers that hinder diversity in academia. This was followed by a lively panel discussion involving academics from a range of STEM disciplines. Approximately 100 people attended this event, of whom 70-80 were Summer School attendees.

Having the ability to meet and converse with like-minded people provided some interesting and invaluable conversations regarding our studies, prospective careers and all things mathematics. It also gave me some much needed guidance for what I might do for honours and what are the potential options available if I chose not to go down that route.

Andrew Grose, Murdoch University

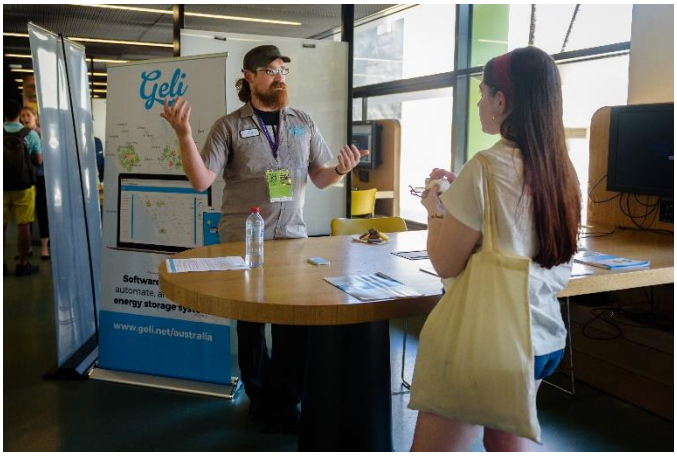
Lunchtime Lectures

Dr Dan Mathews organised four lunchtime lectures over the duration of the Summer School. These were very well attended, and provided light introductions to unusual topics in mathematics. Special mention goes to Julia Collins' LunchMaths talk on Knitting Mathematics, which had audience participation continuing well after the lunch break. The speakers and talk titles for this series were:

- Associate Professor Burkard Polster (Monash University), 'Is 1+2+3+… really equal to -1/12?'
- Dr Julia Collins (AMSI), 'Knitting Mathematics'
- Dr Marty Ross (The University of Melbourne), 'Irrational Thoughts'
- Dr Norman Do (Monash University), 'Tiling'

Careers Afternoon

The Careers Afternoon is always a highlight of the Summer School, providing valuable information and contacts on careers for students. This year the presentations and panel discussion was hosted by Professor Geoff Prince. Presentations on careers in mathematics were given by:



- The APR Intern Program
- Centre for Quantitative Finance, Monash University
- Australian Signals Directorate
- Commonwealth Bank of Australia
- AustMS
- Bureau of Meteorology
- Statistical Society of Australia

This was followed by a panel discussion which additionally included staff from:

- Australian Bioinformatics and Computational Biology Society
- CSIRO's Data61
- GELI

The final part of the Careers Afternoon was an Expo where students were able to individually talk with the presenters. Ninety students participated in the Careers Afternoon, with very positive feedback from presenters and students.

SOCIAL EVENTS

Welcome Reception

On the evening of the first day of the Summer School, the Welcome Reception was held in the foyer of the Green Chemical Futures Building at Monash University (as featured in the publicity for the Summer School). This was an informal function with finger food. Approximately 150 attended.

Choose Maths Networking Event

A Choose Maths dinner was hosted in the first week of the program. This specialised event gave female staff and students the chance to meet over dinner and share their experiences studying and working within the mathematics fields. Attendees also learned more about the AMSI Choose Maths program, the kind of support it offers and its importance within the community. Feedback from both staff and students was positive. The event attracted 36 guests.

Weekly BBQs

A mid-week BBQ was held at lunchtime on Wednesday in each week of the Summer School. The final three were held in the Rock Garden outside the Mathematics Building, and were in high demand with queues stretching along the length of the building. Senor BBQ was universally acclaimed as the most popular barbeque stall.

Speaking to people from different backgrounds and universities really expanded my views on education and culture in other states, and I've made good friends that I'd like to see again. The social aspect of AMSI ended up being my favourite.

Ryan Turner, University of Western Australia

Excursions

Three weekend excursions were organised specially for students visiting from outside of Melbourne. On the first weekend we braved inclement weather to travel to Phillip Island to see the penguin parade, and on the second weekend one excursion indulged themselves in the Yarra Valley and another journeyed along the Great Ocean Road to the Twelve Apostles. These were all fully subscribed, and thoroughly enjoyed by all.

Movie Maths

Our resident maths at the movies expert, Associate Professor Burkard Polster, organised a weekly maths movie night for the first three weeks of the Summer School, enabling students and lecturers to relax after intensive coursework.

Closing Dinner

The closing dinner was held in central Melbourne and attended by 144 guests, including 116 students. The dinner was an entertaining and enjoyable conclusion to the Summer School with short speeches and presentations from participants, as well as lecturers and staff from the School of Mathematical Sciences.

In my opinion, the whole AMSI summer school was amazing, with three things making my experience:

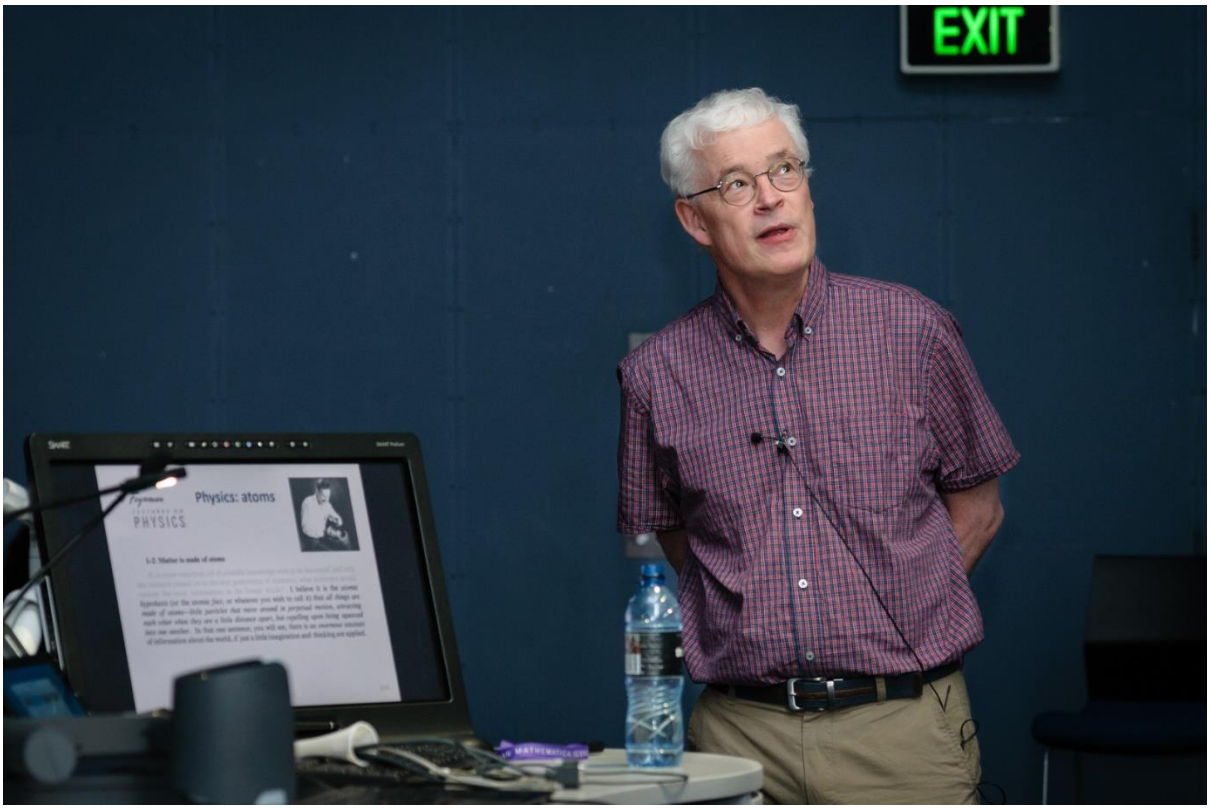
1) The education was amazing, learning interesting mathematical topics from engaging lecturers. Everything I learnt will appear in some form or another in my future studies.

2) The people I met and bonded with made the experience. There was never a lonely moment, meeting new people from all walks of life. Studying with such people made the experience that much more enjoyable. I feel like I made friendships that will last a lifetime.

3) The extra programs made available were very interesting. I have made many cherished memories, from simple lunchtime lectures to exploring the natural sights of Melbourne. These allowed for a getaway from the university life.

Daniel Hutchings, The University of Western Australia

PUBLIC LECTURE



We were very fortunate to have the University of Oxford's Professor Nick Trefethen FRS deliver the Public Lecture for the 2018 Summer School. Professor Trefethen is a leading expert on Numerical Analysis and has published many popular textbooks on this topic. The Public Lecture was held at the Caulfield campus of Monash University. One hundred and nineteen people attended the public lecture, which included 59 students from the Summer School. Professor Trefethen spoke on the topic of `*Discrete or Continuous?*' This exploration of the mathematical and scientific world was followed by a wide-ranging discussion with the speaker. Professor Trefethen also gave a seminar on the same day in the School of Mathematical Sciences, which was attended by approximately 20 Summer School participants.

I enjoyed the events after the course lectures like the lunchtime lectures, the movie nights, Public Lecture. These extra events made me realize that Mathematics can be fun to learn and there is so much we can do with what we know in Mathematics.

Samten Choden, Australian National University

STUDENT PROFILES

Summer of Maths Proves a Winner

Replacing sun and sand with maths and AMSI's Summer School 2018 at Monash University proved the chance of a lifetime for PhD student Elizabeth McCarthy.

With a Choose Maths Grant assisting with travel and accommodation costs, the University of Southern Queensland student enjoyed being immersed in her field and engaging with new ideas and perspectives at the Melbourne event.

"The classes inspired me to look beyond my official course material and discover open source material online. This led to the development of connections between theory and application of machine learning principles," she says.

It also affirmed her PhD focus on machine learning to capture location specific rainfall during drought trends and produce continually updated medium term forecasts meaningful to the agricultural sector.

"The experience at AMSI Summer School has further supported my choice of machine learning applications as the focus of PhD research and turbo charged my desire to finish," she confirms.

As for what comes after her studies, Elizabeth admits to being dazzled by the buffet of choices on display during the careers afternoon.

"The event gave me the opportunity to observe and entertain the idea of different career opportunities. I am more appreciative of the necessity of maintaining a connection to industry." she admits.

Currently supervising undergraduates interested in engineering applications of the area, she also has plans for a new project.

"Later in the year, I plan to utilise what I have learned in a professional development technology demonstrator project on analysis of the impact of student assessment deadlines clusters," she reveals.

About the Choose Maths Grants

Funded by BHP Billiton Foundation as an initiative of the Choose Maths project, the Choose Maths grants are designed to provide full or partial support for Australian female mathematical sciences students and early-career researchers to participate in the AMSI Flagship programs.

Awarded on a competitive basis by the Choose Maths Grant Committee, this funding supports women to build and extend their skills and professional networks by providing financial support to attend and/or assist with caring responsibilities.

Discovering New Horizons at AMSI Summer School

Perfect preparation for his Honours research, AMSI Summer School 2018 gave University of Adelaide's Michael Sandford an exciting introduction to the emerging field of Statistical Machine Learning.

"The knowledge I gained has served as an excellent basis for my honours project, in which I will be learning and applying complex machine learning techniques such as random forests and boosting to mass spectrometry data," he explains.

One of the big takeaways for Sandford, who hopes to work in industry, is the broad commercial application of statistics. As the data age sets in, career opportunities are only set to grow.

"With an interesting array of speakers from various companies, the careers afternoon solidified my interest in this area, and potentially widened the scope of job opportunities available to me."

Juggling a student income, it was only thanks to the support of an AMSI Travel Grant that Sandford was able to attend the Melbourne-based event.

"Without a Travel Grant I likely wouldn't have attended the AMSI Summer school despite being interested in the event. It was crucial in supporting me financially," he said.

Financial barriers are a common issue, with such funding key to increasing student attendance at such events. Opportunities, Michael says, are critical to provide students with in-depth field knowledge and networking.

"Travel Grants are an important initiative, since they increase the number of students able to attend useful events like Summer School. Training events particularly useful for students whose home universities aren't equipped to provide training or networking," he says.

Now focused on his Honours research and eyeing future opportunities, Sandford is thankful for his recent experience at Monash University's Clayton campus.

"I thoroughly enjoyed AMSI Summer School 2018. It was well organised and executed, and provided me with valuable knowledge, networking, and careers information. I'm thankful for the travel grant that allowed me to attend."

Delivered as part of AMSI's flagship research training program, AMSI Summer School 2018 was jointly funded by the Department of Education and Training and the Australian Mathematical Sciences Institute, with support from Monash University, AustMS, ANZIAM, the BHP Billiton Foundation (supporting the Choose Maths Travel Grants), and other event sponsors.

FEEDBACK ANALYSIS

Fifty nine percent of attendees completed the post event feedback form commenting on their experiences at the 2018 Summer School. On the whole, the survey data suggests that this program continues to be integral to the mathematical sciences landscape in the higher education sector, giving students a platform to make valuable networks, broaden their knowledge and open up possibilities for future study and career paths in mathematics and statistics. In rating their overall experience where 1 signalled Poor performance and 10, Excellent, the average rating for the 2018 program was 9.8.

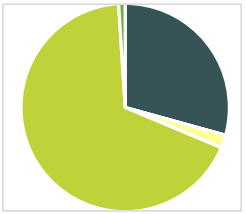
Of those that completed the survey, 46% of students cited their motivation for attending was to gain credit towards their degree. An additional 42% attended to broaden their knowledge and 7% attended to learn from a specific lecturer.

Once again, the AMSI Summer School program demonstrated to participants the importance of mathematical sciences qualifications and its wide and varied application in industry. Fifty five percent of survey respondents noted that participating in the program strengthened their resolve to pursue a PhD in mathematics (33% Agreed; 22% Strongly Agreed), while 58 percent of students felt the Careers Afternoon event provided good information and advice about careers and job opportunities (Agreed 30%; Strongly Agreed 28%).

Below is a further breakdown of thoughts and comments regarding the 2018 program.

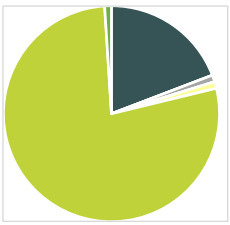
OVERALL, SCHOOL WAS OF A HIGH STANDARD

Strongly Agree	68%
Agree	29%
Neutral	2%
Disagree	0%
Strongly Disagree	1%

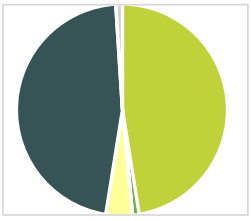


OVERALL, THE SCHOOL WAS WELL-ORGANISED

Strongly Agree	78%
Agree	19%
Neutral	2%
Disagree	0%
Strongly Disagree	1%

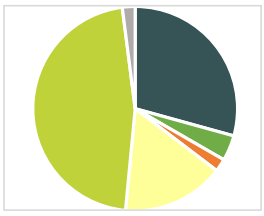


THE COURSES OFFERED PROVIDED A GOOD VARIETY OF SUBJECTS



Strongly Agree	47%
Agree	47%
Neutral	4%
Disagree	1%
Strongly Disagree	1%

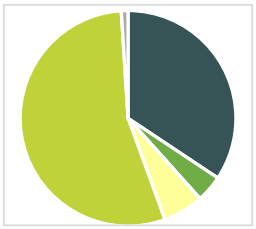
I MADE USEFUL CONTACTS AND NETWORKS AT THE SUMMER SCHOOL



Strongly Agree	47%
Agree	29%
Neutral	18%
Disagree	4%
Strongly Disagree	2%

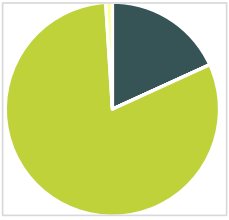
I WILL APPLY KNOWLEDGE GAINED FROM THE SCHOOL TO MY CURRENT AND FUTURE STUDIES/ACTIVITIES

Strongly Agree	55%
Agree	34%
Neutral	6%
Disagree	4%
Strongly Disagree	1%



I WOULD RECOMMEND THE SUMMER SCHOOL TO OTHERS

Strongly Agree	81%
Agree	18%
Neutral	0%
Disagree	0%
Strongly Disagree	1%



Coming to summer school I had very different expectations, thinking it will be like usual university classes. Instead, I was surprised by fun-filled inspiring events and talks, amazing lectures and stimulating conversations. I met incredible people, made notable connections, learned helpful new techniques, got thinking about maths and its place in society and found support and inspiration from fellow females in math. My only regret was not doing more. So all in all 10/10 for the summer school with the added bonus of very helpful and friendly staff and welcoming Monash students. Will be back again!

Danielle Parau, The University of Melbourne

COMMITTEES

Program Committee

- Simon Clarke (AMSI Summer School 2018 Director), Monash University (Chair)
- Geoff Prince (Director), Australian Mathematical Sciences Institute
- Paul Ulrick (Program Manager, Research and Higher Education), Australian Mathematical Sciences Institute
- Anthony Henderson (AMSI Summer School 2017 Director), The University of Sydney
- Andrew Eberhard (AMSI Summer School 2016 Director), RMIT University
- Stephan Tillman, The University of Sydney
- Murray Elder, The University of Newcastle
- Bronwyn Hajek, The University of South Australia
- Kais Hamza, Monash University
- Pierre Portal, The Australian National University
- Louise Ryan, University of Technology Sydney

Organising Committee

- Simon Clarke (AMSI Summer School 2018 Director), Monash University
- Paul Ulrick/Geoff Prince/Chloe Pearse (Program Manager, Research and Higher Education), Australian Mathematical Sciences Institute (AMSI)
- Catherine Parsons/Anna Muscara (Project Coordinator, Research & Higher Education), Australian Mathematical Sciences Institute (AMSI)
- Anna Haley, Monash University
- Gertrude Nayak, Monash University
- Karen Hogeboom, Monash University
- Angelika Nikola-Arvela, Monash University

The director Simon and the Monash Administration team did an impeccable job in organising and running the AMSI event. They were always very friendly and open to conversation, taking great care in the students progress and wellbeing during the school. Information was always provided timely, and there was never a minute where I was unaware of an AMSI event.

Daniel Hutchings, The University of Western Australia

AMSI SUMMER SCHOOL 18

IN THE MATHEMATICAL SCIENCES

ITERATIVE METHODS FOR SPARSE MATRICES
Assoc. Prof. Timothy Moroney, QUT

LOW-DIMENSIONAL TOPOLOGY
Assoc. Prof. Jessica Purcell, MONASH
Dr Daniel Mathews, MONASH

MATHEMATICAL RELATIVITY AND LORENTZIAN GEOMETRY
Assoc. Prof. Todd Oliynyk, MONASH
Dr Andy Hammerlindl, MONASH

MATHEMATICS OF EXTENSIONAL FLOWS
Assoc. Prof. Yvonne Stokes, ADELAIDE

PROBABILISTIC METHODS AND RANDOM GRAPHS
Prof. Nicholas Wormald, MONASH
Dr Jane Gao, MONASH

PROBABILITY, COMPLEX ANALYSIS AND LATTICE MODELS
Dr Laurie Field, ANU
Dr Gregory Markowsky, MONASH

STATISTICAL MACHINE LEARNING
Dr Lamiae Azizi, SYDNEY

TOPOLOGICAL DATA ANALYSIS
Dr Vanessa Robins, ANU
Dr Katharine Turner, ANU

8 JANURAY – 2 FEBRUARY 2018

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