

## Conference Booklet

University of Newcastle  
July 2–4, 2014



# Contents

Welcome to AMSSC14	4
AMSSC2015: We Want You!	5
List of Participants	6
Keynote Speakers	7
Conference Timetable	10
Talk Abstracts	14
Women in Mathematics Special Interest Group	27
Transport Information	28
Campus Map	29
Conference Dinner	30



# Welcome to AMSSC14

Welcome to the third Australian Mathematical Sciences Student Conference. We hope that in the presented talks give you an insight into the work being done across the mathematical sciences, and that the following days will provide many opportunities for catching up with old friends and making new ones. Many thanks to all attendees and participants – together you have made the AMSSC possible. We trust that your stay at the University of Newcastle will be both enjoyable and instructive.

Acknowledgments

*The 2014 AMSSC Organising Committee*

**To presenters:** Each conference room is equipped with a whiteboards, projector and computer having Adobe Acrobat and Microsoft Powerpoint installed. To avoid delays, we ask that presenters load their slides onto these computers during the break prior to their talk. Alternatively, presenters may connect personal laptops to the projector using VGA. In this case, we ask that the presenter tests compatibility of their laptop with the projector during a prior break.

# AMSSC2015: We Want You!

We hoping to continue development and expansion of the AMSSC as an annual event, and as Australia's leading mathematical sciences student conference. As such we are looking for people willing to take over hosting the 2015 at their institution.

One of the premises of the AMSSC philosophy is that it be organized for students by students. This not only provides Honours, Masters and PhD students opportunities to network and present their work, but also gives them a chance to participate in the planning of a conference. The members of the AMSSC2014 committee have found this experience invaluable, and would recommend anyone who is interested to apply.

You will need:

- Some motivation.
- A reliable group of people to form an organising committee.
- An understanding of the logistics of putting on an event at your university.

You will gain:

- Valuable experience at filling applications for grants.
- New friends and academic contacts.
- Some nice CV padding.

If you think you and some friends are ready to take on the task, please have a chat to one of the current or previous organisers! Hosting bids are to be emailed to the conference address [amssc2014@newcastle.edu.au](mailto:amssc2014@newcastle.edu.au), and the successful applicant announced at the 2014 AustMS Annual Meeting.

# List of Participants

Name	Email Address
Andrew Holder	abh920@uowmail.edu.au
Angus Griffith	u4868055@anu.edu.au
Benedict Morrissey	benedictmorrissey@gmail.com
Calum Robertson	calum.robertson@monash.edu
Cameron Rogers	cameron.rogers@gmail.com
Chaturi Bhaskaran	u4681540@anu.edu.au
Christopher Banks	christopher.banks@newcastle.edu.au
Christopher Bourne	chris.bourne@anu.edu.au
Christopher Chung	christopher.chung@anu.edu.au
Cyriac Grigorious	cyriac.grigorious@uon.edu.au
Daniel Sutherland	c3028366@uon.edu.au
Fabian Rigterink	fabian.rigterink@gmail.com
Guohun Zhu	guohun.zhu@usq.edu.au
Hannah Bull	u4673164@anu.edu.au
Hannah Keese	u5025630@anu.edu.au
Heath Winning	heath.winning@uon.edu.au
Hilary Hunt	u5018938@anu.edu.au
Joshua Chen	jaycech3n@gmail.com
Julie Curry	julie.currie@uon.edu.au
Koen van den Dungen	koen.vandendungen@anu.edu.au
Mark Bugden	u5328909@anu.edu.au
Matt Skerritt	matthew.skerritt@uon.edu.au
Matthew Tam	matthew.tam@uon.edu.au
Michael Cromer	mccromer.g@gmail.com
Michael Rose	michael.gerard.rose@gmail.com
Minh Canh Tran	mctran51@hotmail.com
Mitchell Riley	mitchell.v.riley@gmail.com
Montek Gill	mgil8937@uni.sydney.edu.au
Naghmana Tehseen	ntehseen@students.latrobe.edu.au
Novi Herawati Bong	c3171900@uon.edu.au
Oday Shakori	oday.shakori@uon.edu.au
Rachel Bunder	rachel.bunder@uon.edu.au
Ragib Zaman	r.zaman@maths.usyd.edu.au
Sachini Jayasooriya	sachini.jayasooriya@uon.edu.au
Shuai Liu	liushuai04235@gmail.com
Yitao Lei	u5020678@anu.edu.au
Yuehua Li	yh.li.veronica@gmail.com

# Keynote Speakers

## Dr Michael Coons

University of Newcastle  
michael.coons@newcastle.edu.au



MY LIFE IN  $\$mathmode\$$   
10:00am Wednesday 2nd July, VG07

I will survey my career both mathematically and personally offering advice and opinions, which should probably be taken with so many grains of salt that it makes you nauseous. (Note: Please bring with you a sense of humour and all of your preconceived notions of how your life will turn out. It will be more fun for everyone that way.)

**Biography:** Dr Michael Coons Jr is a Lecturer of Mathematics at the University of Newcastle. Michael obtained his PhD in Analytic Number Theory from Simon Fraser University in 2009, under the supervision of Dr Peter Borwein and Dr Stephen Kwok-Kwong Choi. Before coming to Newcastle in 2012, Michael was a Fields-Ontario Postdoctoral Fellow, which involved spending time at both the University of Waterloo and the Fields Institute in Toronto. Last year Michael was awarded a DECRA (Distinguished Early Research Career Award) from the Australian Research Council.

## Dr Vera Roshchina

Federation University Australia  
v.roshchina@federation.edu.au



GEOMETRIC PROPERTIES OF ILL-POSED CONIC SYSTEM  
10:00am Thursday 3rd July, VG07

I will talk about the geometric properties of conic problems and their interplay with ill-posedness and the performance of numerical methods. This includes some new results on the facial structure of general convex cones, preconditioning of feasibility problems and characterisations of ill-posed systems.

**Biography:** Dr. Vera Roshchina is a Research Fellow at Collaborative Research Network, Federation University Australia. Her major research interest is the geometric aspects of conic optimisation. She has published over 20 research papers in leading international journals on topics ranging from nonsmooth analysis and real complexity to dynamical billiards and game theory. She collaborates with several international research centres and universities, including Carnegie-Mellon University, University of Waterloo, Tel Aviv University and Centre of Mathematical Modeling at the University of Chile. She received her Ph.D. from the City University of Hong Kong, and prior to moving to Australia held a Ciencia 2008 Researcher position at the University of Evora, Portugal.

# A/Prof Matthew Simpson

Queensland University of Technology  
matthew.simpson@qut.edu.au



MATHEMATICAL MODELS OF TRANSPORT THROUGH  
CROWDED ENVIRONMENTS  
10:00am Friday 4th July, VG07

Many biological environments, both intracellular and extracellular, are often crowded by large molecules or inert objects which can impede the motion of cells and molecules. It is therefore essential for us to develop appropriate mathematical tools which can reliably predict and quantify collective motion through crowded environments.

Transport through crowded environments is often classified as anomalous, rather than classical, Fickian diffusion. Over the last 30 years many studies have sought to describe such transport processes using either a continuous time random walk or fractional order differential equation. For both these models the transport is characterized by a parameter  $\alpha$ , where  $\alpha = 1$  is associated with Fickian diffusion and  $\alpha < 1$  is associated with anomalous subdiffusion. In this presentation we will consider the motion of a single agent migrating through a crowded environment that is populated by impenetrable, immobile obstacles and we estimate  $\alpha$  using mean squared displacement data. These results will be compared with computer simulations mimicking the transport of a population of such agents through a similar crowded environment and we match averaged agent density profiles to the solution of a related fractional order differential equation to obtain an alternative estimate of  $\alpha$ . I will examine the relationship between our estimate of  $\alpha$  and the properties of the obstacle field for both a single agent and a population of agents; in both cases  $\alpha$  decreases as the obstacle density increases, and that the rate of decrease is greater for smaller obstacles. These very simple computer simulations suggests that it may be inappropriate to model transport through a crowded environment using widely reported approaches including power laws to describe the mean squared displacement and fractional order differential equations to represent the averaged agent density profiles.

More details can be found in Ellery, Simpson, McCue and Baker (2014) *The Journal of Chemical Physics*, 140, 054108.

**Biography:** A/Prof Matthew Simpson obtained a Bachelor of Engineering degree from the University of Newcastle in 1998 and a PhD from the University of Western Australia in 2004. Between 2003 and 2010 he was a Research Fellow and then Australian Postdoctoral Fellow at the University of Melbourne. Since 2010 he has been at the Queensland University of Technology, currently as an Associate Professor. Simpson's primary area of expertise is the use of computational techniques for solving differential equations and studying interacting random walk models. In 2012, Simpson was awarded the J.H. Michell Medal.

# Prof Brian Alspach

University of Newcastle

brian.alspach@newcastle.edu.au



LOST SPELUNKERS, COPS AND ROBBERS AND IS SOMEONE TRYING TO DESTROY MY NETWORK?  
6:30pm Wednesday 2nd July, VG07

What do the three elements of the title have in common is the utility of using graph searching as a model. In this talk I shall discuss the relatively brief history of graph searching, several models currently being employed, several significant results, unsolved conjectures, and the vast expanse of unexplored territory.

**Biography:** Professor Brian Alspach received his Ph.D from the University of California, Santa Barbara in 1966 under the supervision of Professor Paul Kelly. Before retiring in 1998, he taught at Simon Fraser University for 33 years where he is Professor Emeritus.

Prof Alspach's specialisation is Discrete Mathematics with an emphasis on Graph Theory. His thesis and many early publications dealt with tournaments and digraphs. He is an expert in the areas of permutation groups and their actions on graphs, as well as graph decompositions and factorisations. A highly influential survey paper of Alspach focused on the problem of finding Hamilton cycles in vertex-transitive graphs, and his work on generalised Petersen graphs is also well-known and respected. For some years, he has led a research project focusing on *determining the number of pursuers required to find an intruder in a graph*, with a particular emphasis on Cayley graph. The work is partially funded by the Canadian government's Communications Security Establishment. Prof Alspach is a very active researcher, even after his retirement.

Above all else, Prof Alspach is a friendly mathematician who continues to give support and encouragement to young mathematicians. Another of Alspach's continuing interests in the mathematics of gambling, in particular, poker. He has written more than 140 articles in popular poker magazines, such as Poker Digest and Canadian Poker magazines. Outside mathematics, he also has great interest in football and baseball.

# Wednesday 2nd July

	VG02	VG07
9:00–10:00		Registration
10:00–11:00		Keynote Lecture: <b>Michael Coons</b> (p.7)
11:00–11:30		Morning Tea
11:30–12:30	<b>Montek Gill</b> (p.18) <b>Ragib Zaman</b> (p.26)	<b>Shuai Liu</b> (p.21) <b>Guohun Zhu</b> (p.26)
12:30–14:30		Lunch
14:30–15:30	<b>Calum Robertson</b> (p.22) <b>Julie Currie</b> (p.18)	<b>Matt Skeritt</b> (p.21) <b>Chaturi Bhaskaran</b> (p.14)
15:30–16:00		Afternoon Tea
16:00–17:30	<b>Patrick Andersen</b> (p.14) <b>Cyriac Grigorious</b> (p.19) <b>Dushyant Tanna</b> (p.24)	<b>Michael Rose</b> (p.23) <b>Naghmana Tehseen</b> (p.25) <b>Yuehua Li</b> (p.20)
17:30–18:30		
18:30–19:30		Public Lecture: <b>Brian Alspach</b> (p.10)

## Thursday 3rd July

	VG02	VG07
10:00–11:00	Keynote Lecture: <b>Vera Roschina</b> (p.8)	
11:00–11:30	Morning Tea	
11:30–13:00	<b>Oday Shakori</b> (p.23) <b>Andrew Holder</b> (p.19) <b>Sachini Jayasooriya</b> (p.19)	<b>Joshua Chen</b> (p.17) <b>Minh Canh Tran</b> (p.25)
13:00–14:30	Lunch	
14:30–15:30	<b>Chris Bourne</b> (p.15) <b>Koen van den Dungen</b> (p.25)	<b>Benedict Morrissey</b> (p.22) <b>Daniel Sutherland</b> (p.23)
15:30–16:00	Afternoon Tea	
16:00–17:00	<b>Mark Bugden</b> (p.16) <b>Michael Cromer</b> (p.17)	<b>Hannah Keese</b> (p.20) <b>Hannah Bull</b> (p.16)
18:30	Conference Dinner: the Grain Thai	

## Friday 4th July

	VG02	VG07
09:30–10:30	Keynote Lecture: <b>Matthew Simpson</b> (p.9)	
10:30–11:30	Morning Tea (Women in Mathematics Special Interest Group)	
11:30–12:30	<b>Matthew Tam</b> (p.24) <b>Rachel Bunder</b> (p.16)	<b>Christopher Banks</b> (p.14) <b>Novi Herawati Bong</b> (p.15)
12:30-13:30	Closing and presentation of prizes	

# Talk Abstracts

## MINIMUM WEIGHT RESOLVING SETS OF GRID GRAPHS

**Patrick Andersen** (University of Newcastle)  
Joint work with Cyriac Grigorious, Mirka Miller

For a simple graph  $G = (V, E)$  and for a pair of vertices  $u, v \in V$ , we say that a vertex  $w \in V$  resolves  $u$  and  $v$  if the shortest path from  $w$  to  $u$  is of a different length than the shortest path from  $w$  to  $v$ . A set of vertices  $R \subseteq V$  is a resolving set if for every pair of vertices  $u$  and  $v$  in  $G$ , there exists a vertex  $w \in R$  that resolves  $u$  and  $v$ . The minimum weight resolving set problem is to find a resolving set  $M$  for a weighted graph  $G$  such that  $\sum_{v \in M} w(v)$  is minimum, where  $w(v)$  is the weight of vertex  $v$ . In this paper, we explore the possible solutions of this problem for grid graphs  $P_n \square P_m$  where  $3 \leq n \leq m$ . We give a complete characterisation of solutions whose cardinalities are 2 or 3, and show the existence of solutions whose cardinalities are  $2n - 2$ .

Subject area(s): Discrete Mathematics and Combinatorics

---

## CLASSIFYING GROUPS WITH THE INDEPENDENCE PROPERTY.

**Christopher Banks** (University of Newcastle)

The Independence Property (inspired by the work of Jacques Tits) may be satisfied by a group of automorphisms of a locally finite tree. I will discuss how we may be able to classify groups acting on trees that satisfy the Independence Property or its generalisations.

Subject area(s): Algebra and Number Theory

---

## THE WIENER-HOPF FACTORISATION FOR RANDOM WALKS

**Miss Chaturi Bhaskaran** (Australian National University)

A random walk,  $\{S_n\}_{n \geq 0}$ , is the sequence of partial sums of  $\mathbb{R}$ -valued independent and identically distributed random variables,  $\{X_k\}_{k \geq 1}$ :

$$S_0 = 0 \quad \text{and} \quad S_n = \sum_{k=1}^n X_k.$$

From the definition of this stochastic process, I will introduce some of its important properties: the strong Markov property and its ladder process. I will conclude with an intuitive justification of the Wiener-Hopf factorisation, as well as how to use it to decompose the distribution of the random walk at a geometrically stopped time into the distributions of its maximum and minimum value.

Subject area(s): Statistics

---

## DECREASING THE UPPER BOUND OF $ex(n; 4)$

**Miss Novi Herawati Bong** (University of Newcastle)

Joint work with Joe Ryan, Mirka Miller

The problem of extremal graphs with girth 5, which is proposed in 1975, aims to determine the maximum number of edges in a graph on a given number of vertices containing neither triangles nor squares. In general, let  $ex(n; t)$  be the maximum number of edges in a graph of order  $n$  and girth  $g$  at least  $t + 1$ . There are 34 numbers of  $n$ , where the exact values of  $ex(n, 4)$  are known. For other values of  $n$ , we only know the upper and lower bound. In this talk, we decrease the upper bound for certain values of  $n$  by showing that  $ex(n; 4) = \frac{(d^3+d)}{2}$ , where  $n = d^2 + 1$ , for  $d \geq 4, d \neq 7, 57$ , is not achievable.

Subject area(s): Discrete Mathematics and Combinatorics

---

## RELATIVE CYCLIC COHOMOLOGY AND THE BULK-EDGE CORRESPONDENCE

**Chris Bourne** (Australian National University)

The quantum Hall effect is a rare physical system whose explanation relies on (non-commutative) topology. More recent developments have considered quantum Hall systems with a boundary, where it is predicted that the Hall current flows along the edge of the sample. In this talk we will show how relative cyclic cohomology gives us an insight into comparing topological data on the boundary and the interior. We will also discuss further applications and generalisations of these ideas.

Subject area(s): Mathematical Physics

---

## T-DUALITY IN STRING THEORY

**Mr Mark Bugden** (Australian National University)

T-duality in string theory is an equivalence between two theories with different spacetime geometries. The simplest manifestation of T-duality considers a spacetime with one of the dimensions curled up into a circle of radius  $R$ . In this case, T-duality asserts that string theory on this spacetime is completely equivalent to string theory on a spacetime where one of the dimensions is curled up into a circle of radius  $\frac{1}{R}$ . In this talk, I will give a (gentle) introduction to T-duality and its generalisations.

Subject area(s): Mathematical Physics

---

## THE RANK OF ELLIPTIC CURVES OVER FUNCTION FIELDS OF FINITE FIELDS

**Ms Hannah Bull** (Australian National University)

It is unknown whether the Birch and Swinnerton-Dyer conjecture holds in general for elliptic curves over function fields of finite fields. We show it does hold for elliptic curves whose corresponding elliptic surfaces are dominated by a product of curves, and give an example of a particular family of elliptic curves over function fields of finite fields whose members turn out to satisfy the Birch and Swinnerton-Dyer conjecture and also have arbitrarily large rank.

Subject area(s): Algebra and Number Theory

---

## HEURISTIC METHODS FOR PICKING ITEMS FOR EXPERIMENTAL SETS

**Ms Rachel Bunder** (University of Newcastle)

Joint work with Natasha Boland, Andrew Heathcote

Psychologists and other experiment designers are often faced with the task of creating, or picking, sets of items to be used in experiments. These sets are used to test how one or more factors affect some situation, e.g. a psychologist may want to see how humans respond differently to short words compared to long words. These sets must 'match', i.e. be as similar as possible, on all other attributes that could affect response.

Previously, we have explored definitions of similarity for experimental data sets and have developed a MIP to solve this problem. However, this approach struggles when solving larger problems. In this talk we will explore a variety of heuristic methods and

compare the results to existing metaheuristics.

Subject area(s): Operations Research

---

## AN INTRODUCTION TO TOPOLOGICAL QUANTUM FIELD THEORY

**Joshua Chen** (Australian National University)

Topological quantum field theories (TQFTs) have their origins in physics, where they were first formulated using gauge theory and path integrals, and then rigorously axiomatized by Atiyah in the late 80's. It was Witten who in a revolutionary paper of 1989 first showed that they were applicable to more than "just" quantum physics, showing that the famous Jones polynomial invariant of knots could be computed using a  $(2 + 1)$ -dimensional Yang-Mills TQFT. Since then TQFTs have been used to obtain topological invariants for knots and other low-dimensional manifolds, found applications in representation theory, and there is even some promise that they could yield a novel and robust way of performing quantum computations.

In this talk we will start with an easy introduction to category theory, and then see the existence of analogous structure between categories of vector spaces (and linear maps between them) and categories of  $n$ -manifolds (and  $(n + 1)$ -dimensional cobordisms between them). Following on from these observations we will define an  $(n + 1)$ -topological quantum field theory, and finish off with a teaser on how  $(2 + 1)$ -TQFTs in particular could potentially be used to implement quantum computers.

Subject area(s): Algebra and Number Theory

---

## REPRESENTATION THEORY OF THE VIRASORO ALGEBRA

**Mr Michael Cromer** (Australian National University)

The representation theory of infinite-dimensional Lie algebras is relevant in many areas of modern mathematical physics. In particular, this talk will be a gentle introduction to the Virasoro algebra, its representations, and how it applies to aspects of Logarithmic Conformal Field Theory.

Logarithmic CFTs are now known to describe non-local observables in the scaling limit of critical lattice models, for example percolation and polymers, and to form an integral part of our understanding of string theories on supermanifolds. They are also believed to arise as duals of three-dimensional chiral gravity models, fill out hidden sectors in non-rational theories with non-compact target spaces, and describe certain transitions in various incarnations of the quantum Hall effect.

Subject area(s): Mathematical Physics

---

## CHOOSING A TIME STEP FOR SIMULATING WAVES WITH CHANGING POLARISATION

**Miss Julie Currie** (University of Newcastle)  
Joint work with A. Prof Colin Waters

Computer simulations of Ultra Low Frequency (ULF) waves in near Earth space involve numerically solving a hyperbolic differential equation using a finite difference time domain (FDTD) method. In the ionosphere the Hall conductivity provides a mechanism for wave polarisation rotation. To understand wave propagation it is important for computer simulations to capture the rotation of the wave through different regions. In digital signal processing it is well known that data must be sampled consistent with the bandwidth. The Nyquist condition provides the maximum timestep,  $dt$ , which leads to the Courant condition in computer simulations. The Courant condition is a known way of calculating  $dt$  prior to simulation based on wave phase speed and spatial resolution. This talk will show computer simulations of wave propagation through the ionosphere and discuss implications of rotation for the Courant condition.

Subject area(s): Mathematical Physics

---

## HYPERBOLIC GLUING EQUATIONS OVER COMMUTATIVE RINGS

**Mr. Montek Gill** (University of Sydney)

Given (ideally) triangulated 3-manifolds, we may be interested in finding hyperbolic structures on those manifolds. A method to do this was introduced in Thurston's Princeton lecture notes 'The geometry and topology of three-manifolds'. This method involved finding solutions over  $\mathbb{C}$  to certain equations which arose from labellings of the edges of the triangulation by elements of  $\mathbb{C}$ . These equations involve only integer coefficients and so may be interpreted over more general rings. This was done by Feng Luo showing that much of the theory can be viewed as purely algebraic and that there is topological information which can be extracted from the knowledge that solutions to the equations exist over some ring. This talk introduces the gluing equations and associated constructions, in particular a representation of the fundamental group of the manifold into  $\mathrm{PSL}(2, R)$  where  $R$  is our ring over which we study our equations.

Subject area(s): Geometry and Topology

## ON THE METRIC DIMENSION OF CIRCULANT AND HARARY GRAPHS

**Mr Cyriac Grigorious** (University of Newcastle)

Joint work with Paul Manuel, Mirka Miller, Bharati Rajand, Sudeep Stephen

A metric generator is a set  $W$  of vertices of a graph  $G(V, E)$  such that for every pair of vertices  $u, v$  of  $G$ , there exists a vertex  $w \in W$  with the condition that the length of a shortest path from  $u$  to  $w$  is different from the length of a shortest path from  $v$  to  $w$ . In this case the vertex  $w$  is said to distinguish or resolve the vertices  $u$  and  $v$ . The minimum cardinality of a metric generator for  $G$  is called the metric dimension. The metric dimension problem is to find a minimum metric generator in a graph  $G$ . In this paper, we make a significant advance on the metric dimension problem for circulant graphs  $C(n, \pm\{1, 2 \dots j\})$ ,  $1 \leq j \leq \lfloor n/2 \rfloor$ ,  $n \geq 3$ , and for Harary graphs.

Subject area(s): Discrete Mathematics and Combinatorics

---

## DOES A TUMOUR METABOLISM FACILITATE LOCAL INVASION?

**Mr Andrew Holder** (University of Wollongong)

Tumour development is a complex process with many well observed yet poorly understood processes. As such there are many opportunities for mathematics to help contribute to this field of research. One such tumour mechanism that I hope to better understand with mathematics is aerobic glycolysis.

Aerobic glycolysis or the “Warburg Effect” is a process that is part of the metabolism of the vast majority of tumours. While the physical process of aerobic glycolysis is well understood, the reasons that tumours acquire this mechanism are still debated. A consequence of aerobic glycolysis is the production of excess  $H^+$  ions that result in the acidification of the tumour microenvironment. This aspect of aerobic glycolysis has led to a proposition that this process provides a mechanism for local invasion known as the acid-mediation hypothesis. In this talk I will provide a brief explanation of the acid-mediation hypothesis and discuss recent results I have obtained examining models adapted from population ecology.

Subject area(s): Applied Mathematics

---

## OPTIMIZATION OF GRAPH BASED CODES FOR BELIEF PROPAGATION

**Sachini Jayasooriya** (University of Newcastle)

Joint work with Sarah J. Johnson, Lawrence Ong, Regina Berretta

A low-density parity-check (LDPC) code is a linear block code described by a sparse parity-check matrix, which can be efficiently represented by a bipartite Tanner graph.

A key performance measure of a coding scheme is its decoding threshold, which is the maximum noise level at which it can correct errors. Density evolution is an efficient method to analyse the performance of LDPC code ensemble. It determines expected iterative decoding performance of a particular code ensemble by tracking the probability density function of Tanner graph edge messages through the iterative decoding process. This problem for the code designer is then to search for the ensemble with the best threshold from which a specific code may then be chosen.

The code optimization of LDPC codes is a non-linear cost function maximization problem, where the decoding threshold is the cost function and the Tanner graph structure and edge distribution gives the variables to be optimized. In previous research of code optimization, the structure of the LDPC Tanner graph is determined via trail and error or exhaustive search, while only the edge fractions within a given structure are optimized using Differential Evolution algorithm.

The basic problem addressed in this work is how to optimize the Tanner graph so that the decoding threshold is as large as possible. We introduce a new code optimization technique which involves the search space range which can be thought of as minimizing randomness in differential evolution or limiting the search range in exhaustive search. At the same time, we propose a new nested method to optimize both the structure and edge distribution for LDPC codes. This is particularly important for Multi-edge type LDPC codes where it is not clear a priori which structures will be good.

Subject area(s): Optimisation

---

## KHOVANOV HOMOLOGY

**Hannah Keese** (Australian National University)

Khovanov homology is an example of the power of categorification: it is an invariant of knots and links that extends the information given by the Jones polynomial.

We will discuss the construction of Khovanov homology and some applications. Time permitting, we will also introduce one of its variants, namely annular Khovanov homology, from the perspective of representation theory.

Subject area(s): Algebra and Number Theory

---

## DOUBLE DIFFUSIVE INTERLEAVING WITH A SMALL PRANDTL NUMBER: PROPERTIES OF THE STEADY STATE SOLUTION

**Yuehua Li** (University of New South Wales)

Joint work with Trevor McDougall

Double diffusive convection is driven by two different density gradients that have different rates of diffusion. A linear stability analysis indicated that it is possible that a steady state is eventually achieved where finite amplitude interleaving motions stop growing, and both the temperature and salinity budgets are in balance. Combining a linear stability analysis with experimental flux laws, we examined double diffusive interleaving as it progresses from a linear instability towards finite amplitude. The interleaving motions were studied from a small initial perturbation with scales and slopes as found in the linear instability analysis, through three evolving stages, and steady state conditions were found. It was also found that the strength of the existing experimental flux law for diffusive interfaces needs to be increased significantly, relative to the corresponding laboratory finger fluxes. This is valid regardless of the size of the Prandtl number. However, if the Prandtl number is small, it requires the environmental stability ratio to be larger than the counterpart in large Prandtl number cases. The results of the study have implications for how we understand the oceans. There are implications on the magnitudes of fluxes across diffusive and finger interfaces. Besides, there are also implications for how these interleaving motions could be parameterised in intermediate-scale and large-scale ocean models.

Subject area(s): Applied Mathematics

---

## A VERSION OF BUNDLE TRUST REGION METHOD WITH LINEAR SUB-PROBLEM FOR NONCOVEX OPTIMIZATION

**Mr Shuai Liu** (RMIT University)

Joint work with Andrew C. Eberhard, Yousong Luo

We present a special bundle trust region method for minimizing locally Lipschitz and prox-regular functions. The para convexity of such functions allows us to use the local convexification model and its convexity properties. The model is to be controlled during the iteration process such that the linearization errors are always positive. The trust region is formed by infinity norm so we have a linear subproblem in each iteration. We show that if the convexification succeeds the algorithm converges to a stationary point. Preliminary numerical experiments on academic test problems show that the algorithm is reliable and efficient.

Subject area(s): Optimisation

---

## COMPUTATION OF AN IMPROVED LOWER BOUND TO GIUGA'S PRIMALITY CONJECTURE

**Matt Skeritt** (University of Newcastle)

Joint work with Jonathan Borwein, Christopher Matiland

Our most recent computations tell us that any counterexample to Giuga's 1950 primality conjecture must have at least 19,908 decimal digits. Equivalently, any number which is both a Giuga and a Carmichael number must have at least 19,908 decimal digits. This bound has not been achieved through exhaustive testing of all numbers with up to 19,908 decimal digits, but rather through exploitation of the properties of Giuga and Carmichael numbers. This bound improves upon the 1996 bound of Borwein, Borwein, Borwein, and Girgensohn. We present the algorithm used, and discuss technical challenges and challenges to further computation.

Subject area(s): Computational and Numerical Methods

---

## REPRESENTATIONS AND QUANTIZATION

**Mr Benedict Morrissey** (Australian National University)

Starting with a symplectic manifold describing a classical mechanical system, quantization gives a Hilbert space of quantum states for an associated quantum system. When we use certain orbits (coadjoint orbits) of Lie group actions for our symplectic manifold, the action of the group on the classical system results in an action on the quantum state space - a representation of the group. This talk will look at what this approach can tell us about the representations of lie groups and algebras, including the links to A-branes that appear when A-branes are used to quantize the system.

Subject area(s): Algebra and Number Theory

---

## THE INFLUENCE OF SMALL-SCALE INHOMOGENEITIES ON THE EVOLUTION OF THE UNIVERSE

**Mr Calum Robertson** (Monash University)  
Joint work with T. Oliynyk (Supervisor)

Inspection of the Newtonian limit in relativistic gravity has been a useful tool up to this point, both within the solar system and farther afield. Our question here is whether or not it can be (safely) pushed into the domain of cosmological modelling. Relativistic gravity models involving some serious symmetry assumptions currently weigh heavily on the interpretation of cosmological observations, and we will discuss why this is the case, as well as some efforts that have been made to improve on these models. Meanwhile, the heavyweight in N-body simulations of gravity-dominated situations is actually Newtonian gravity (sometimes with relativistic corrections). In this project we will aim to establish a sense of closeness between these approaches to cosmology, in an attempt to build a

bridge between small-scale inhomogeneity and the homogeneous "big picture".

Subject area(s): Mathematical Physics

---

## EXPECTATIONS ON FRACTAL IFS ATTRACTORS

**Mr Michael Rose** (University of Newcastle)

Joint work with Laureate Professor Jon Borwein

We present a measure-theoretic foundation for analysing the expectation of any smooth complex-valued function defined over the attractor of an Iterated Function System (IFS). A Chaos-Game algorithm to approximate such expectations naturally follows. This work extends the results of our previous paper, 'Expectations on Fractal Sets', in which such expectations were defined over a restricted class of Cantor-like sets, motivated by the desire to analyse neural spatial distributions.

Subject area(s): Geometry and Topology

---

## REFLECTION AND PROJECTION METHODS FOR NON-CONVEX INVERSE PROBLEMS

**Mr Oday Shakori** (University of Newcastle)

In this talk I will give an introduction about reflection and projection methods, and the application of tools from convex and variational analysis to optimization problems.

Subject area(s): Optimisation

---

## DETERMINANT DEDUCTIONS

**Mr Daniel Sutherland** (University of Newcastle)

Taking our lead from the Hilbert matrix, we will investigate how certain sequences of Hankel determinants converge to zero. Using a classical determinant identity we will bound positive Hankel determinants from above, and provide sufficient conditions to ensure their monotonic decrease.

Subject area(s): Algebra and Number Theory

---

## RECONSTRUCTION ALGORITHMS FOR BLIND PTYCHOGRAPHIC IMAGING

**Mr Matthew Tam** (University of Newcastle)

Joint work with R. Hesse, D.R. Luke, S. Sabach

In scanning ptychography, an unknown specimen is illuminated by a localized illumination function resulting in an exit-wave whose intensity is observed in the far-field. A ptychography dataset is a series of these observations, each of which is obtained by shifting the illumination function to a different position relative to the specimen, with neighbouring illumination regions overlapping. Given a ptychographic dataset, the blind ptychography problem is to simultaneously reconstruct the relative phase of the specimen and illumination function. In this talk, I will introduce an alternating minimization-type algorithm for the problem.

Subject area(s): Optimisation

---

## SOCIAL NETWORK ANALYSIS: A SURVEY ON USAGE OF SITES

**Mr Dushyant Tanna** (University of Newcastle)

In this paper we will discuss about the usage of social sites such as facebook, twitter and many more. As we know that social networking sites has just modified the way of usage of public sharing with the help of digital technology. This means that people were using SN even before the invention of digital technology but extensive use of social networking sites have come up with recent wide spread usage. People create social networking profile on website to share their private information, updates in social life and personal emotions to a limited or wide number of users. This enables creation of interconnected network and groups. Some of the main resource for the usage of social networking sites like chatting, messaging, emails, file sharing, video calling, voice chatting, blogging and discussion groups. Some of the Social networking sites from their origin in the order of their release are as sixdegrees.com, Live Journal, Blank Planet, Cyworld, Friendster, LinkedIn, MySpace, Hi5, Orkut, Flickr, Facebook (Harvard), Yahoo360, Youtube, Facebook(Corporate), Windows Live Space, Twitter and Facebook (everyone). There are many more other than these also. With some of them were just designed to frame a marketing strategy for re-launch of certain brands. Since most of the software that deals with digital communities are free for end user so every user of site can modify its own content

Subject area(s): Discrete Mathematics and Combinatorics

---

## SOLUTIONS OF PDE VIA VESSIOT THEORY AND SOLVABLE STRUCTURES

**Mrs Naghmana Tehseen** (La Trobe University)

I will discuss the problem of computing the integrable (Frobenius integrable) sub-distributions of the non-integrable Vessiot distribution of second order partial differential equations (PDEs). I will show that how to impose solvable structures on a second order PDE so as to determine the largest integrable distributions and the subsequent production of group invariant solutions.

Subject area(s): Differential Equations

---

## THE PELL EQUATION

**Minh Canh Tran** (Universite de Fribourg)

Proposed method of solving the PELL equation using programming tools: with unexpected results. For every minimum positive solution found, infinity of solutions of the family group are behind by a method of bounding and recurrence. Things is extremely hard for our predecessors but easily preformed by modern computers of larges memories.

Subject area(s): Algebra and Number Theory

---

## Globally Non-Trivial Almost-Commutative Manifolds

**Koen van den Dungen** (Australian National University)

Joint work with Jord Boeijink

One of the main motivations for mathematical physicists to study noncommutative geometry is the special case of almost-commutative geometry, which can be used to describe (classical) gauge theories in physics. However, in the usual approach these gauge theories turn out to always be globally trivial. In this talk I will describe how almost-commutative manifolds can be generalised to describe globally non-trivial gauge theories as well. In the first half of the talk I will give a basic introduction to almost-commutative manifolds and gauge theories in physics, and I will explain what it means for these gauge theories to be globally trivial. In the second half I will then briefly sketch how this framework can be adapted to allow for globally non-trivial gauge theories. This talk is based on joint work with Jord Boeijink (Radboud University Nijmegen) [arXiv:1405.5368].

Subject area(s): Mathematical Physics

---

## THE EULER CHARACTERISTIC OF TORIC VARIETIES

**Ragib Zaman** (University of Sydney)

Toric varieties are a special class of algebraic varieties which have the combinatorial data of a fan (a collection of cones) associated to them. The fan encodes geometric and topological properties of the variety such as smoothness, compactness and cohomology. As such, problems related to the variety can often be answered by studying the fan, which is usually more tractable. I will explain how to construct toric varieties from a fan and give an outline of how to compute their Euler characteristic.

Subject area(s): Geometry and Topology

---

## MEASURING SIMILARITIES BETWEEN GENE EXPRESSION DATA BASED ON GRAPH ISOMORPHISM

**Mr Guohun Zhu** (University of Southern Queensland)

Time series in plant gene expression data are always small sample size and large number of genes. It is difficult to apply the conventional synchrony detection methods to find the dominant signals. This study proposes a horizontal visibility graph isomorphism algorithm (HVGI) to evaluate multiple time series based on a faster weighted horizontal visibility algorithm. It is proved that graph isomorphism problem between two horizontal visibility graphs can be solved in linear time. By using the dark-light cycle of the gene expression time series from *Arabidopsis thaliana*, the HVGI illustrates a higher performance to pick up the dominant diurnal changes than the correlation and coherence methods.

Subject area(s): Mathematics in Science and Engineering

# Women in Mathematics Special Interest Group

The Women in Mathematics Special Interest Group (WIMSIG) has been active group of the Australian Mathematical Society since early 2013.

It aims to:

- Support women to achieve their potential in all areas of mathematics;
- Facilitate the recruitment and retention of women in mathematical careers;
- Encourage women to have active careers in the mathematical sciences.

On Friday, a Women in Mathematics morning tea will be held in the mathematics building. Everyone (no matter your gender) is welcome to attend.

# Transport Information

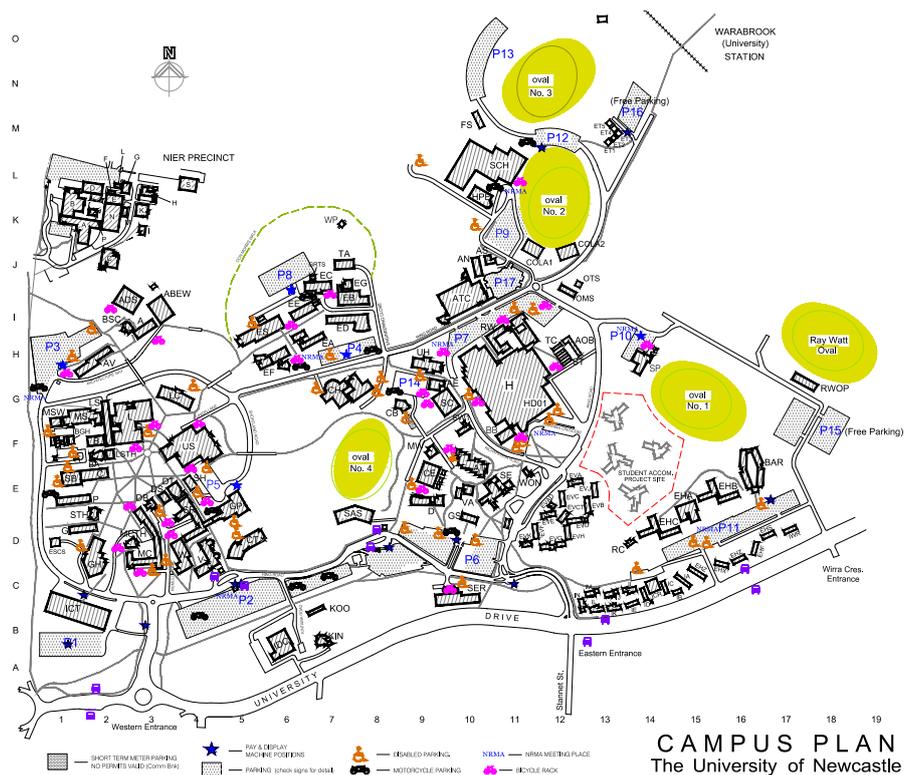
Buses operate between Newcastle city and the university's campus, the most direct routes being 100 and 226. The closest bus stop to the conference venue is Mathematics Building, Ring Road, Callaghan.

Warabrook train station is on the Hunter line and is located at the edge of the campus. Trains run between Warabrook and Newcastle approximately every half an hour. To get to the mathematics building from Warabrook station either take the free university run shuttle bus (operating on a loop around the campus) or take a 10min walk to the mathematics building.

Detailed trip information for both Newcastle buses and trains can be obtained online from <http://www.sydneytrains.info/>.

For those with cars, general parking on campus cost \$4.30 per day. Coin and credit card operated ticket machines are located throughout the campus. The machines do not give change. Alternatively, free parking is available in Carparks 15 and 16. (See the campus map in the next section).

# Campus Map



Key landmarks:

- **D4:** Mathematics V-Building, & Mathematics Bus Stop
- **F4:** Shortland Hub
- **O15:** Warabrook Train Station

Conference registration will take place in the courtyard of the Mathematics Building. Presentations will take place in rooms VG02, VG07 and VG10 all of which are adjacent to the courtyard and are located on the ground floor.

The Shortland Hub contains various food outlets, a post office, a bank, a pharmacy and many other shops.

# Conference Dinner

The conference dinner will be held at

Grain Thai  
54 Beaumont Street  
Hamilton NSW 2303

The restaurant is booked from 6:30pm and dinner will commence at 7:00pm. To avoid delays, please arrive as close to 6:30 as possible.

**Note:** If you are navigating using Google maps, be aware that a Google maps search for “54 Beaumont Street” will give the incorrect location. To get the correct location, search instead for “the Grain Thai”. The restaurant is only 450m from Hamilton train station. Bus routes 100, 226 leaving from outside the mathematics building also have stops near the restaurant.

