AUSTRALIAN MATHEMATICAL SCIENCES STUDENT CONFERENCE

HOBART 2015

Conference Booklet

University of Tasmania

Nov 30 - Dec 02, 2015

Contents

Welcome to AMSSC15

Welcome to the fourth Australian Mathematical Sciences Student Conference. We hope that the talks presented give you an insight into the work being done across the mathematical sciences within Australia, and that the following days will provide numerous opportunities to both catch up with old friends and meet some of your fellow postgraduate students from around Australia. Many thanks to all speakers and attendees - together you have made the AMSSC possible. We hope that your stay at the University of Tasmania will be both enjoyable and instructive.

The 2015 AMSSC Organising Committee.

To presenters: The lecture theatre booked for talks is equipped with four whiteboards, a projector and a computer with Adobe Acrobat Reader installed. To avoid delays, we ask that presenters load their slides 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.

Conference Timetable

Monday 30th November

9:30-9:50	*Registration (Entrance Foyer on Level 2)*	
9:50-10:00	*Opening*	
10:00-11:00	**Jaci Brown** (Plenary)	Fun things you can do with a PhD in Maths
11:00-11:30	*Morning Tea*	
11:30-12:30	Edward Dodridge	Eddy Compensation in Wind-Driven Subtropical Gyres and Implications for Biological Productivity
	Nicholas Ham	The mod-m diagram monoids
12:30-14:00	*Lunch*	
14:00-15:00	Tom Dyer	Intercalating carbon nanotubes in graphene folds
	Xin An	Undular bores in collodal media
15:00-15:30	*Afternoon Tea*	
15:30-16:00	Nirav Shah	Regularity of bounded weak solutions in the critical dimension

Tuesday 1st December

10:00-11:00	**Ben Burton** (Plenary)	Knots, computers, and a tangled career
11:00-11:30	*Morning Tea*	
11:30-12:30	John Harrison	Random Walks on Matrix Groups
	Jesse Swan	Galaxy classification using emission-line fitting
12:30-14:30	*Lunch*	
14:30-16:00	Arwin Kahlon	Particle Scattering in an External Field
	Mark Bugden	Photon Spheres around Higher Dimensional Black Holes
	Michael Cromer	From Power Series to Vertex Algebras in Mathematical Physics
∼16:30-18:30	*Preachers (further information to be announced)*	
19:00	*Conference Dinner: Shipwrights Arms Hotel*	

Wednesday 2nd December

10:00-11:00	**David Ridout** (Plenary)	The joy of mathematical physics and how to give a better talk than this one
11:00-11:30	*Morning Tea*	
11:30-13:00	Ainsley Pullen	Bullseye! Rings and Quivers in Persistent Homology
	Ellen Manning	Observational Probes of Helium Ignition in Low-Mass Stars
	Tianshu Liu	Towards $N = 2$ Minimal Models
13:00-14:30	*Lunch*	
14:30	*Excursion*	

Note that:

(i) registration will be held at 9:30am Monday morning in the entrance foyer on level 2 of the mathematics and physics building;

(ii) the opening and talks will take place in Lecture Theatre 3, which is located on level 3;

(iii) morning and afternoon teas, when scheduled, will take place in room 328; and

(iv) lunch is not officially provided, however we will be identifying a place to go for lunch each day, we encourage everyone to come along and get to know your fellow attendees better.

AMSSC16 - We Want You!

We are hoping to continue developing and expanding the AMSSC as an annual event, and as Australia's leading mathematical sciences student conference. As such we are looking for people interested in hosting the 2016 AMSSC at their institution. One of the premises of the AMSSC philosophy is that it be organised for students by students. This not only provides Honours, Masters and PhD students opportunities to network and present their work, but also obtain experience with planning, organising and running an academic conference. The members of the AMSSC15 committee, along with previous organising committees, have found this experience invaluable, and would recommend anyone who is interested to apply.

You will need:

(i) Some motivation;

(ii) A reliable group of people to form an organising committee; and

(iii) An understanding of the logistics required to plan, organise and run an academic conference at your university.

You will gain:

(i) Valuable experience at filling applications for grants;

(ii) New friends and academic contacts; and

(iii) Some nice CV padding.

If you think you and some friends are ready to take on the task, please have a discussion with the current or previous organisers! Hosting bids are to be emailed to the conference address `conference@amssc.org`, and the successful applicant will be announced at the 2015 AustMS Annual Meeting.

Plenary Speakers

■ 4.1 Jaci Brown - CSIRO

Fun things you can do with a PhD in Maths

10:00am Monday 30th November, Physics Lectures Theatre 3

When I began my undergraduate degree in mathematics I had little idea where it would take me. I had some vague thoughts of designing aeroplane timetables and a fear I would end up being a maths teacher. I should not have worried. After completing my PhD I have had an exciting, but very challenging career - one that I could never have anticipated. My career has included:

- Climate change projections for Pacific Islanders;
- The physics of El Nino Southern Oscillation;
- Tracking water parcels through the atmosphere to understand where rain comes from;
- Predicting grass growth in QLD to estimate the weight gain of beef cattle;
- Following imaginary ocean water parcels as they try to cross the equator;

- Exploring how information about the ocean can aid Military strategy;
- Understanding how the Australian diet will change due to global warming;
- Attending international conferences at least once each year;
- Writing articles for The Conversation and numerous TV, radio and newspaper interviews (including The Project);
- Presenting the weather on the Weather Channel and the Tasmanian ABC evening news;
- And meanwhile gave birth to triplets who are now six years old.

I would like to share some of this research with you and the demonstrate ways that maths can help to change the world we live in.

About: Jaci is currently a Senior Research Scientist at CSIRO studying many aspects of climate variability and change in the Tropical Pacific Ocean.

Jaci's PhD was undertaken jointly with the University of NSW and the CSIRO in Hobart. Following this Jaci took up a Postdoctoral Associate position at Yale University looking at the mechanical energy of the tropical Pacific. She has now returned to the CSIRO in Hobart as part of the Centre for Australian Weather and Climate Research (CAWCR).

`http://www.marine.csiro.au/~bro753/`

■ 4.2 Ben Burton - University of Queensland

Knots, computers, and a tangled career

10:00am Tuesday 1st December, Physics Lectures Theatre 3

How can a human tell whether a loop of string is intrinsically tangled? How can a *computer* tell? How does this relate to P vs NP? We discuss some of the mathematics behind these problems, along with some unexpected approaches motivated by a highly non-linear career path in and out of academia, and back and forth between pure mathematics, computer science, and econophysics.

About: Ben is currently Associate Professor in the School of Mathematics and Physics at the University of Queensland, Brisbane, Australia, where he has just finished a QEII Fellowship. He has previously worked in the mathematics departments at RMIT University, the University of Melbourne and Oklahoma State University, as well as a three-year stint in the finance industry.

His main research area is computational geometry and topology, with a focus on spaces in three and four dimensions. He is particularly interested in developing practical software in this setting, and in understanding the intrinsic difficulty of fundamental problems in this field. He draws on techniques from a variety of areas, including pure mathematics, computer science, combinatorics and operations research.

`http://www.maths.uq.edu.au/~bab/`

■ 4.3 David Ridout - Australian National University

The joy of mathematical physics and how to give a better talk than this one

10:00am Wednesday 2nd December, Physics Lectures Theatre 3

As with any technical field, talking mathematics to an audience of non-specialists (or specialists!) is a difficult task. The internet has many guides on how to give a good math talk, but you'll all by now have noticed that these guides are almost never followed by actual practising mathematicians. Here, I intend to bore you with some of the math physics that I do, while also pointing out some of my bad habits that make the topic seem less fascinating than it actually is. You are encouraged to call out, pantomime style, if I neglect to acknowledge any of these habits.

[**Warning:** This talk may contain traces of opinion, prejudice and tomfoolery.]

About: David is an Australian Research Fellow at the Australian National University working in mathematical physics. His current research aims to further our knowledge of the algebraic structures underpinning logarithmic conformal field theories. Expected outcomes include an improved understanding of the applications to statistical physics and string theory, as well as developing beautiful connections with pure mathematics.

`http://people.physics.anu.edu.au/~drt105/`

Abstracts

Homogeneous and non-homogeneous nanofluid models.

Rashid Ahmad - University of Queensland

In this study, the hydro and thermodynamic boundary layer trends of the coupled nanofluid and surface interface is investigated by considering the homogeneous and non-homogeneous nanofluid models. The influence of various pertinent parameters such as viscosity, thermal conductivity, and nanoparticle volume fraction is examined for the heat transfer enhancement over the nanofluid-surface interface. The analytical and numerical results are presented graphically, and found in a good agreement.

Subject area(s): Applied mathematics

Undular bores in collodal media

Xin An - University of Wollongong

The propagation of coherent light with an initial step intensity profile in a colloidal media is studied using modulation theory. In general, the intensity step breaks up into an undular bore (or dispersive shock wave) and an expansion fan. By employing a rigorous approach based on the Whitham modulation theory, we investigate dispersive shock waves arising from colloidal equation. This model finds important applications in nonlinear optics. Our theory predicts the formation of dispersive shocks with entirely controllable properties. Numerical simulations confirm these results.

Subject area(s): Applied mathematics

Photon Spheres around Higher Dimensional Black Holes

Mark Bugden - Australian National University

Black holes are an interesting class of objects in general relativity. Around spherically symmetric black holes, there is a radius at which light may orbit, forming a surface called a photon sphere. Rotating black holes have more interesting photon spheres, where orbits are not confined to lie in a plane. In this talk, I will speak about my work (in progress) in generalising these orbits to higher dimensional spacetimes.

Subject area(s): Geometry and topology

From Power Series to Vertex Algebras in Mathematical Physics

Michael Cromer - Australian National University

Taylor and Laurent series expansions are powerful weapons in a mathematician's arsenal, making tractable many problems, and making possible many insights, not least in the areas of physics, dynamical systems, and differential geometry.

However, power series themselves carry many subtleties that require careful attention. When treated correctly, a rich new algebraic structure appears, one which has deep and far-reaching implications.

This talk will introduce and motivate these ideas with the classic example of the 'delta function', one of the most important aspects of the theory.

Subject area(s): Analysis

Eddy Compensation in Wind-Driven Subtropical Gyres and Implications for Biological Productivity

Edward Doddridge - University of Oxford

Joint work with David Marshall

Large-scale Ekman-induced downwelling is believed to suppress biological activity in subtropical gyres. Despite much work, the nutrient budget of these gyres remains poorly understood; estimates of primary productivity are consistently higher than estimates of nutrient supply. The existence of eddy compensation in the Southern Ocean, in which an eddy induced overturning circulation largely compensates the Ekman driven overturning circulation, is widely accepted. By analysing output from an idealised eddy-resolving model we show that eddy compensation also occurs within wind-driven gyres. By taking area integrals of vertical potential vorticity fluxes within the subtropical gyre, we show that Ekman induced downwelling is opposed and largely compensated by eddy induced upwelling. Using Lagrangian particle tracking techniques, we confirm that the Ekman-induced downwelling observed in the Eulerian-mean velocity fields, is suppressed when the particles are advected by the full time-varying velocity fields. The implications of these results for biological productivity are explored by the inclusion of a simple nutrient in our model. Our results may explain the unexpectedly high levels of biological productivity observed in subtropical gyres despite large-scale Ekman-induced downwelling.

Subject area(s): Applied mathematics

Intercalating carbon nanotubes in graphene folds

Tom Dyer - University of Wollongong

Folding graphitic materials have the potential to create complex structures with new properties. Intercalating molecules into these folds is an interesting method of one-dimensional functionalisation of a graphene sheet. We investigate the incorporation of a single-walled carbon nanotube into folded graphene structures and between sheets of graphene. The optimal curved structure caused by both the elastic and van der Waals energies is examined using variational calculus. Results are shown to match with molecular dynamics simulations.

Subject area(s): Applied mathematics

The mod-m diagram monoids

Nicholas Ham - University of Tasmania

Given a positive integer m, the (planar) mod-m diagram monoid consists of diagrams from the (planar) partition monoids such that the number of upper and lower vertices contained in each block are congruent modulo m. A presentation by way of generators and relations has previously been established for the mod-m monoid. This talk will outline how the author identified and established generators for the planar mod-m diagram monoid, along with relations that appear to form a presentation of the planar mod-2 diagram monoid, while also describing some of the other results contained in the author's thesis.

Subject area(s): Discrete mathematics/algebra

Random Walks on Matrix Groups

John Harrison - University of Newcastle

I will describe the Poisson boundary of a discrete family of matrix groups under certain weak restrictions. The Poisson boundary is a space associated with every random walk on a locally compact group which encapsulates the behaviour of the walks at infinity and gives a description of certain harmonic functions on the group in terms of the essentially bounded functions on the boundary. I will introduce random walks and the Poisson boundary during the talk.

Subject area(s): Discrete mathematics/algebra

Particle Scattering in an External Field

Arwin Kahlon - University of Tasmania

In this talk I will give a summary of the work done in the context of particle scattering in an external field. I will start with a scalar particle scattering off an external complex scalar field in minkowski space and extend this formulation to an external field in Schwarzchild geometry. This methodology can then be extended to photons scattering in an external field (e.g. gravity) which has implications for the use of quantum encryption on a global scale.

Subject area(s): Applied mathematics

Towards $N = 2$ Minimal Models

Tianshu Liu - Australian National University

Joint work with David Ridout

Conformal field theory is an essential tool of modern mathematical physics with applications to string theory and to the critical behaviour of statistical lattice models. The symmetries of a conformal field theory include all angle-preserving transformations. In two dimensions, these transformations generate the Virasoro algebra, a powerful symmetry that allows one to calculate observable quantities analytically.The symmetries of a conformal field theory may be strictly larger than the Virasoro algebra. One possibility which is crucial importance to string theory applications is that of supersymmetry, where the Virasoro algebra is extended by a given number of fields. My project aims to investigate certain carefully chosen examples of N=1 and N=2 superconformal field theories using the arsenal of mathematical technology and physical insight that has been built up over the last five years.

Subject area(s): Discrete mathematics/algebra

Observational Probes of Helium Ignition in Low-Mass Stars

Ellen Manning - University of Tasmania

The most extreme event in the life cycle of Solar-type stars is the explosive ignition of helium under electron degenerate conditions. Although the theoretical reasoning for the occurrence of this violent 'helium-flash' is well understood, observational evidence is virtually non-existent because the effects on the surface properties are subtle, and occur on much shorter timescales than that of the total stellar lifetime. Due to this, the precise details of the process remain unclear. A helium-flash involves the complete rearrangement of the stellar structure in a turbulent and non-equilibrium process. The initial focus is on post-RGB evolutionary rates. Specifically, the variation of red giant branch stars with stellar mass and chemistry, which results in a biased sample of chemical evolution tracers. While previous studies have highlighted some issues with their own metallicity distribution models, they generally ignore this bias. As far as we know, this mass bias has not yet been thoroughly investigated.

Subject area(s): Applied mathematics

Bullseye! Rings and Quivers in Persistent Homology

Ainsley Pullen - University of Queensland

Joint work with Clément Maria

Quiver representations are algebraic objects which are constructed by identifying vector spaces and maps between them with the nodes and arrows of a directed graph respectively. Quiver theory has applications in computer vision where it helps identify objects or in data analysis to determine trends. These applications are through a related field of persistent homology, which studies the life-span of features such as holes within evolving shapes. Gabriel's Theorem is the seminal result in quiver theory, which states for an important set of quivers, that they can be represented by a unique sum of indecomposable objects and that these objects are mathematically well behaved. Furthermore for A_n-type quivers we can identify these indecomposables which make them useful for computational applications. However issues arise when we attempt to use integer homologies because they form abelian groups rather than the vector spaces required for quiver representations. Yet being able to use integer homologies would be incredibly beneficial because they are more informative than those with coefficients from a field.

Subject area(s): Algebra

Regularity of bounded weak solutions in the critical dimension

Nirav Shah - University of Queensland

In this talk we will consider bounded weak solutions to the following vector-valued Euler-Lagrange system:

$$-\text{div}\,\big(A(x,u)Du\big) = g \quad \text{in } \Omega \tag{5.1}$$

for Ω a bounded open domain in $\mathbb{R}^2$. Under quite mild assumptions on the principal part, $A(x,u)Du$, and inhomogeneous part, g, we will show that every bounded weak solution of (5.1) is Hölder continuous. Since the dimension of Ω is 2 we are in the critical setting, and hence, cannot use the Sobolev embedding theorem to deduce Hölder continuity. This result resolves a conjecture by Beck and Frehse (2013).

Subject area(s): Applied mathematics

Galaxy classification using emission-line fitting

Jesse Swan - University of Tasmania

TBA

Subject area(s): Applied mathematics

Transportation information

■ 6.1 Hobart Airport to Hobart City

The Hobart Airport Shuttle Service operates buses between the Hobart Airport and accommodations around Hobart, including the university. The shuttle operates for every departure and arrival. Bookings should be made at least two hours before the pickup time. A taxi rank is also located in front of the airport terminal building. Taxis may be booked in Hobart by calling 131 008.

■ 6.2 Hobart City to the University of Tasmania

The University of Tasmania's Sandy Bay campus is approximately a 30 minute walk from the Hobart CBD along Sandy Bay road (check Google maps). Metro Tasmania routes 51, 52, 53, 54, 55 and 888 all provide transport between the city centre and the university. The closest bus stop to the conference venue is University stop 12.

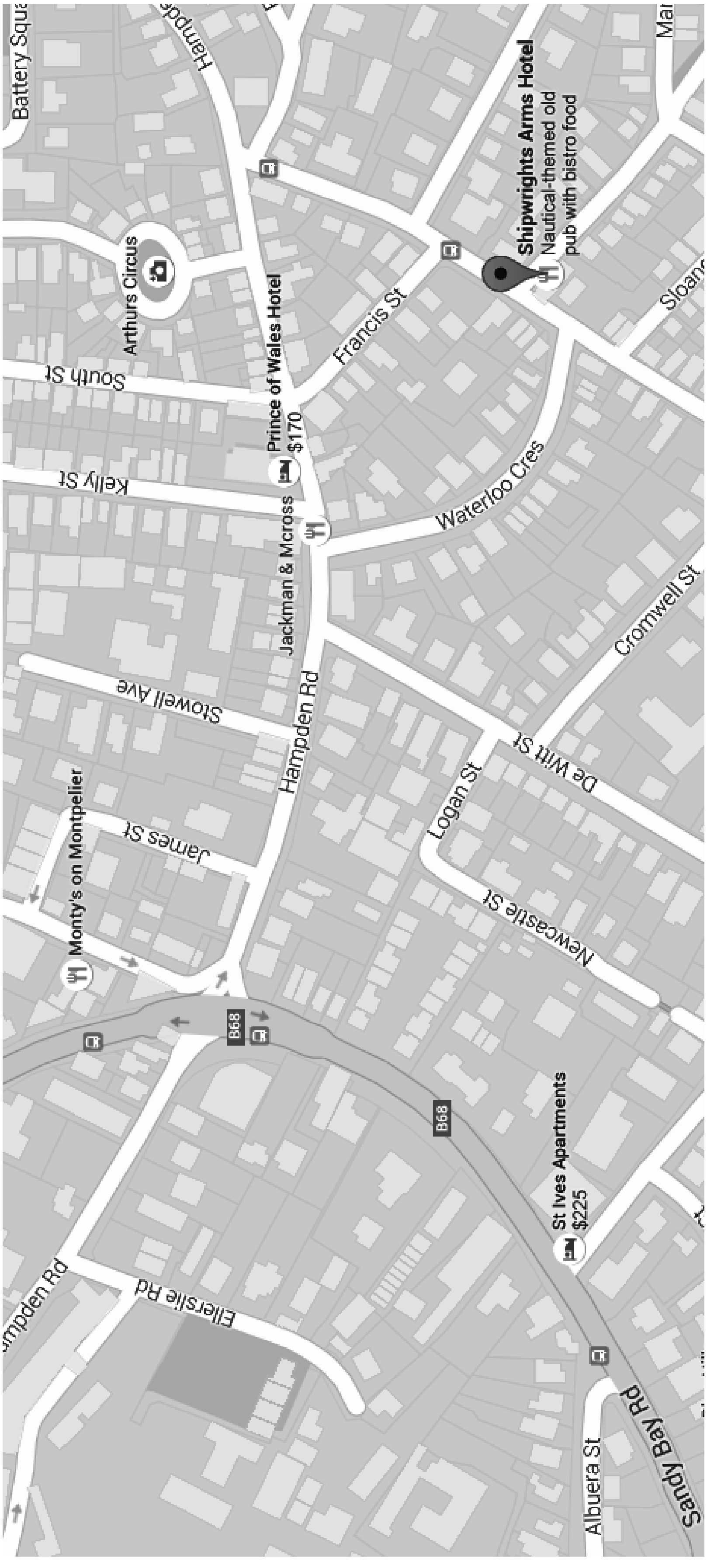
Campus map

The mathematics and physics building is marked by **13** (AU-14) on the above map. Registration will take place in the entrance foyer on level 1, morning and afternoon teas will take place in Room 328, and talks will take place in Lecture Theatre 3.

Conference dinner

The conference dinner will be held at the Shipwrights Arms Hotel, which is located at 29 Trumpeter Street, Battery Point 7004 (there is a map located on the following page).

The restaurant is booked from 7:00pm. To avoid delays, please arrive as close to 7:00pm as possible.


Shipwrights Arms Hotel
Nautical-themed old pub with bistro food
Prince of Wales Hotel
$170
Jackman & Mcross
Arthurs Circus
Battery Squa
Hampden Rd
Francis St
South St
Kelly St
Waterloo Cres
Cromwell St
Stowell Ave
De Witt St
Logan St
James St
Monty's on Montpelier
Newcastle St
B68
St Ives Apartments
$225
Ellerslie Rd
Albuera St
Sandy Bay Rd
Sloane