Mathematical Methods for Applications:
ANZIAM-ZPAMS Joint Conference

11–14 November 2016

Hangzhou, China

ZPAMS

Contents

Introduction

Welcome

It is our great pleasure to welcome you to attend ANZPAMS Conference in Hangzhou, China. This is the historic first conference of ANZIAM to be held in China, run jointly by ANZIAM and the Zhejiang Provincial Applied Mathematics Society, in collaboration with SIAM. This will be an opportunity to explore synergies between two different applied mathematics cultures and to link to a network through a region that has a long tradition of excellence in research and education.

We have worked very hard – together with the local organizers and the dedicated Chairs listed in the conference proceedings – to bring you a high-quality conference for sharing knowledge, exchanging ideas and research experiences in applied mathematics.

Hangzhou is famous for its beautiful landscapes, comfortable living environments and fascinating history. It is the host city of G20 Summit 2016 and the headquarter of Alibaba. The main attraction in Hangzhou is the West Lake, where our conference is being held. We wish all of the delegates of the conference a wonderful time in Hangzhou and an enjoyable stay!

Acknowledgements

First of all, the Organizing Committee gratefully acknowledges the financial and in-kind support from the following sponsors: Australia and New Zealand Industrial and Applied Mathematics (ANZIAM), Zhejiang Provincial Appied Mathematics Society (ZPAMS), Australian Mathematical Sciences Institute (AMSI), Society for Industrial and Applied Mathematics (SIAM), La Trobe University, University of Wollongong, University of South Australia, Zhejiang Sci-Tech University and China Jiliang University.

Secondly, we would like to thank remarkable contributors to this event, including Professor Philip Broadbridge and Associate Professor Dianhui(Justin) Wang from La Trobe University for initiating and organizing this conference, and editing the special issues in ANZIAM Journal; Professor Jueliang Hu from Zhejiang Sci-Tech University and Professor Feilong Cao from China Jiliang University for their great contributions to conference application and logistic aspects; Associate Professor Mark Nelson from University of Wollongong for editing the special issues as a leading guest editor.

Finally, we thank the plenary speakers: Professor Ian Sloan (UNSW Australia), Professor Zongben Xu (Xi'an Jiaotong University), Professor Philip Broadbridge (La Trobe University), Professor Songliang Qiu (Zhejiang Sci-Tech University), Professor Jin Cheng (Shanghai University of Finance and Economy & Fudan University), Dr Alona Ben-Tal (Massey University), Professor Changzheng Qu (Ningbo University), and also all the contributing authors, and session Chairs and local committee members for helping with conference organization, in addition, Dr Yu Guang Wang for his great help in editing the programme.

Organizing Committee

- Philip Broadbridge (La Trobe University, Chair)
- Songliang Qiu (Zhejiang Sci-Tech University, Chair)
- Feilong Cao (China Jiliang University)
- Zuohua Ding (Zhejiang Sci-Tech University)
- Jueliang Hu (Zhejiang Sci-Tech University)
- Tim Marchant (University of Wollongong)
- Mark Nelson (University of Wollongong)
- Julia Piantadosi (University of South Australia)
- Dianhui(Justin) Wang (La Trobe University)

Local Organizers

- Feilong Cao (China Jiliang University)
- Jianming Dong (Zhejiang Sci-Tech University)
- Ping'an He (Zhejiang Sci-Tech University)
- Jueliang Hu (Zhejiang Sci-Tech University)
- Congming Jin (Zhejiang Sci-Tech University)
- Zhong Li (Zhejiang Sci-Tech University)
- Yan Liu (China Jiliang University)
- Weiping Wang (Zhejiang Sci-Tech University)
- Bao-Lin Zhang (China Jiliang University)
- Jianwei Zhao (China Jiliang University)
- Zhenhua Zhou (China Jiliang University)

Plenary Speakers

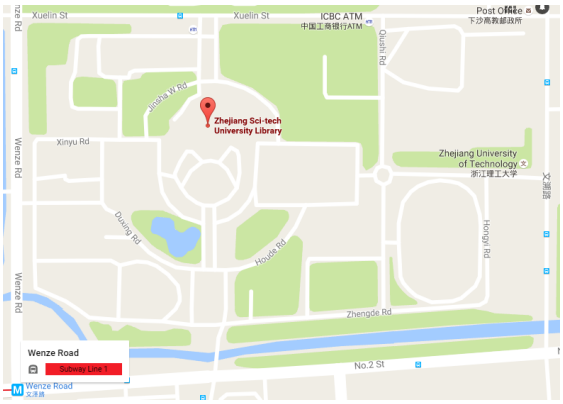
- Dr Alona Ben-Tal (Massey Univeristy)
- Professor Philip Broadbridge (La Trobe Univeristy)
- Professor Jin Cheng (Shanghai University of Finance and Economy & Fudan University)
- Professor Songliang Qiu (Zhejiang Sci-Tech University)
- Professor Changzheng Qu (Ningbo University)
- Professor Ian Sloan (The University of New South Wales, Australia)
- Professor Zongben Xu (Xi'an Jiaotong University)

Conference Venues, Events and Facilities

Venues

On Friday, the conference is being held at Zhejiang Sci-Tech University (ZJSTU). See the map on the left below for the location of Zhejiang Sci-Tech University. On Saturday and Sunday, the conference session is being held at the Ball Room of West Lake Hillview International Hotel Hangzhou (WLHI Hotel). See the map on the right below for the location of the WLHI Hotel.

The invited lectures on Friday will take place in the Lecture Hall in ZJSTU. The invited lectures and all contributed sessions on Saturday and Sunday will be held in the Ball Room in WLHI Hotel.



Zhejiang Sci-Tech University
Friday invited talks and open ceremony

West Lake Hillview International Hotel
All Saturday, Sunday and Monday sessions and conference banquet

Registration

The conference registration will be held from 8:30-8:50am on Friday 11 November at the conference venue of Zhejiang Sci-Tech University. You will receive a package including a name badge.

Reception

The welcome reception will be held from 6-8pm on Thursday 10 November at West Lake Hillview International Hotel Hangzhou. All registered delegates and their guests are invited.

Banquet

The banquet dinner will be held at the West Lake Hillview International Hotel Hangzhou with pre-dinner drinks from 6:00 pm, Sunday 13 November.

Refresh Breaks and Lunches

Morning and afternoon tea and light refreshments will be offered at the conference venue. Lunches and Dinners are included in the registration fee for delegates and their registered guests. They will be available after the last presentations of the morning and the afternoon sessions at the conference venue respectively.

Internet Access

WiFi internet is available in the West Lake Hillview International Hotel. We are sorry but WiFi internet is not available in Zhejiang Sci-Tech University on Friday. Note that Eduroam is not available in Mainland China.

General Information

- For general enquiries or projector/computer/internet problems please see the registration desk.
- Emergency services: for Police and Rescue Service call 110, for Fire Service call 119, for Emergency Medical Service call 120.

Transportation

Routes To Hotel (Start Points)

- Hangzhou International Airport
  Taxi, 60 mins, about 130 RMB, 28 km;
- Hangzhou East Train Station
  Taxi, 35 mins, about 50 RMB, 12.8 km;
- Hangzhou City Bus Station
  Taxi, 18 mins, about 20 RMB, 5.6 km.

Please print the following address of the hotel in Chinese to show the taxi driver if you take a taxi.

杭州蓝天清水湾国际大酒店，莲花峰路37号，近玉皇山路。

For delegates living in West Lake Hillview International Hotel, there will be a shuttle on Friday from the hotel to Zhejiang Sci-Tech University in the morning and a return shuttle following the last talk in the afternoon waiting at the entrance gate of Zhejiang Sci-Tech University. The time details will be informed at conference.

Tour

Friday 11 Nov there will be the largest Qiantang River Tides in the month. We will organize a tour for the tides. The exact time for the tour depends on when the tides appear and will be informed by the organizers in time. The tides most possibly come in the noon or afternoon.

On Monday 14 Nov, we will organize a tour of West Lake, Qiantang River, Tea Farm and G20 Venue for all delegates and their guests who are interested to participate in. Lunch (outside Hotel) and dinner (in Hotel) will be provided.

ANZPAMS CONFERENCE SCHEDULE

	Friday 11	Saturday 12	Sunday 13	Monday 14	
Time	Zhejiang Sci-Tech University	West Lake Hillview Hotel	West Lake Hillview Hotel	West Lake Hillview Hotel	Time
08:30-08:50	**Registration**	**Plenary: Zongben Xu**	**Session**	**Tour**	08:30-09:30
09:00-09:30	**Open Ceremony**				
09:30-10:30	**Plenary: Ian Sloan**	**Plenary: Philip Broadbridge**	**Session**		09:30-10:30
10:30-11:00	Morning Tea	Morning Tea	Morning Tea		10:30-11:00
11:00-12:00	**Plenary: Changzheng Qu**	**Plenary: Jin Cheng**	**Session**		11:00-12:00
12:00-01:30	Lunch	Lunch	Lunch	Lunch	12:00-01:30
01:30-02:30	**Plenary: Songliang Qiu**	**Session**	**Session**	**Tour**	01:30-03:00
02:30-03:30	**Plenary: Alona Ben-Tal**				
		Afternoon Tea	Afternoon Tea		03:00-03:30
03:30-04:00	Afternoon Tea	**Session**	**Session**		03:30-05:00
04:00-05:00	**Tour**				
06:00-08:00	Dinner	Dinner	Conference Banquet	Dinner	06:00-08:00

Coffee, tea, snacks, lunches and dinners will be provided by the organizers in breaks at conference venue every day.

We will organize a tour for Qiantang River Tides on Friday 11 Nov (possibly in the noon or in the afternoon).

On Monday 14 Nov, we will organize a tour of West Lake, Tea Farm and G20 Venue.

Friday 11 November 2016

Venue: Zhejiang Sci-Tech University

Time	Location: **Lecture Hall A**
08:30-08:50	Registration
09:00-09:30	Open Ceremony
09:30-10:30	**Plenary: Ian Sloan**, *The University of New South Wales, Australia* **Title: Designing high-dimensional integration rules** *Chair*: Philip Broadbridge
10:30-11:00	Morning Tea
11:00-12:00	**Plenary: Changzheng Qu**, *Ningbo University* **Title: Blow up solutions and stability of peakons to integrable equations with nonlinear dispersion** *Chair*: Philip Broadbridge
12:00-01:30	Lunch
01:30-02:30	**Plenary: Songliang Qiu**, *Zhejiang Sci-Tech University* **Title: The series expansions of the Ramanujan constant and their applications** *Chair*: Zuohua Ding
02:30-03:30	**Plenary: Alona Ben-Tal**, *Massey University* **Title: Mathematical modelling of the cardio-respiratory system: challenges and opportunities** *Chair*: Zuohua Ding
03:30-04:00	Afternoon Tea

We will organize a tour for Qiantang River Tides on Friday 11 Nov. The exact time depends on the forecast of when the tides come and will be informed by the organizers in time. (Possibly in the noon or in the afternoon)

Saturday 12 November 2016

Venue: West Lake Hillview International Hotel Hangzhou

Time	Location: **Ball Room**
08:30-09:30	**Plenary: Zongben Xu**, *Xi'an Jiaotong University* **Title: Big data: problems and practice** *Chair*: Justin Wang
09:30-10:30	**Plenary: Philip Broadbridge**, *La Trobe University* **Title: Applications of nonclassical symmetries of partial differential equations** *Chair*: Justin Wang
10:30-11:00	Morning Tea
11:00-12:00	**Plenary: Jin Cheng**, *Shanghai University of Finance and Economy & Fudan University* **Title: A new unique continuation for the Lamé equation** *Chair*: Huaixin Cao
12:00-01:30	Lunch
	Contributed Session, *Chair*: Yi Shen
01:30-02:00	**Martin Stynes** **Title: A finite difference method on graded meshes for a time-fractional diffusion equation** *Beijing Computational Science Research Center*
02:00-02:30	**Steven Carnie** **Title: Slip sliding away: how a small bubble in water slips along a hydrophilic surface** *The University of Melbourne*
02:30-03:00	**Yu Guang Wang** **Title: Needlet approximation for isotropic random fields on the sphere** *La Trobe University*
03:00-03:30	Afternoon Tea
	Contributed Session, *Chair*: Steven Carnie
03:30-04:00	**Mark McGuinness** **Title: Modelling steaming Surtseyan ejecta** *Victoria University of Wellington*
04:00-04:30	**Yi Shen** **Title: Image inpainting from partial noisy data by directional complex tight framelets** *Zhejiang Sci-Tech University*
04:30-05:00	**Shu-Ping Wang** **Title: Approximate controllability of population dynamics with size-dependence and spatial distribution** *Hangzhou Dianzi University*

Sunday 13 November 2016

Venue: West Lake Hillview International Hotel Hangzhou

Time	Location: **Ball Room**
	Contributed Session, *Chair*: Dimetre Triadis
08:30-09:00	**Scott Lindstrom** **Title: The Lambert W function in optimization** *The University of Newcastle*
09:00-09:30	**Xiaoping Lu** **Title: A semi-analytic evaluation of finite maturity stock loans under a regime-switching economy** *University of Wollongong*
09:30-10:00	**Yuecai Han** **Title: Pricing perpetual timer option under the stochastic volatility model of Hull-White** *Jilin University*
10:00-10:30	Morning Tea
	Contributed Session, *Chair*: Taihe Fan
10:30-11:00	**Huaixin Cao** **Title: A note on Markovian quantum dynamics** *Shaanxi Normal University*
11:00-11:30	**Simon Williams** **Title: Triangulation and complex geometry** *Flinders University*
11:30-12:00	**Yan Ding** **Title: Size effect of a lipid pool inside of an atheroma lesion on the vulnerability of the plaque failure** *RMIT University*
12:00-01:30	Lunch
	Contributed Session, *Chair*: Simon Williams
01:30-02:00	**Xiangchen Zeng** **Title: On the relation between trinomial lattice and explicit finite difference for a regime-switching model** *University of Wollongong*
02:00-02:30	**Naoyuki Ishimura** **Title: On the convergence of discrete processes with multiple independent variables** *Chuo University*
02:30-03:00	**Xue-Mei Dong** **Title: Learning gradients from nonidentical data** *Zhejing Gongshang University*
03:00-03:30	Afternoon Tea
	Contributed Session, *Chair*: Ze-Rong He
03:30-04:00	**Sen Wang** **Title: An alternative method of concept learning** *Shandong University*
04:00-04:30	**Kazuhiro Yasuda** **Title: On exchange rate control using continuous and impulse stochastic controls** *Chuo University*
04:30-05:00	**Marianito Rodrigo** **Title: Option pricing and volatility estimation in jump-diffusion models: a Mellin transform approach** *University of Wollongong Australia*

Designing high-dimensional integration rules

Ian H. Sloan

The University of New South Wales, Australia
i.sloan@unsw.edu.au

Friday 09:30–10:30 Lecture Hall, Zhejiang Sci-Tech University

Abstract

High-dimensional integration – numerical integration when there are hundreds or thousands of continuous variables – will be an important direction for numerical analysis far into the future. Such problems are arising with increasing frequency, and can be very hard. Much of the focus in this talk will be on applications, in mathematical finance, linear models in statistics, and PDE with random coefficients, the latter typified by flow through a random porous medium. What's new is that for the first time we are beginning to design rules that are both soundly based theoretically, and suitable for particular applications.

Biography

Fellowing his PhD in theoretical degree at the University of London, Professor Ian Sloan joined University of New South Wales (UNSW Australia) in 1965 and promoted to Personal Chair in Mathematics in 1983. He has published some 200 papers on numerical solution of integral equations, numerical integration and interpolation, boundary integral equations, approximation theory, continuous complexity, high dimensional integration and so on. He is a 2001 ISI Highly Cited Author in Mathematics. He received many prizes for his work in computational and numerical mathematics, including the Information Based Complexity Prize, the Lyle Medal of the Australian Academy of Science, and the ANZIAM and Szekeres Medals of the Australian Mathematical Society.

Prof Sloan has been in many editorial boards, including SIAM Joural on Numerical Analysis, Numerische Mathematik, Advances in Computational Mathematics, Journal of Integral Equations and Applications, International Journal of Geomathematics, Foundations of Computational Mathematics and Journal of Complexity. He is a Fellow of the Australian Mathematical Society, the Australian Academy of Science, the Royal Society of New South Wales, the American Mathematical Society and SIAM. From 2003 to 2007, he was the President of the Internal Council for Industrial and Applied Mathematics (ICIAM).

Friday Plenary Talks

Blow up solutions and stability of peakons to integrable equations with nonlinear dispersion

Changzheng Qu

Ningbo University, China
quchangzheng@nbu.edu.cn

Friday 11:00–12:00 Lecture Hall, Zhejiang Sci-Tech University

Abstract

In this talk, we study blow-up mechanism of solutions to an integrable equation with cubic nonlinearities and nonlinear dispersion. We show that singularities of the solutions can occur only in the form of wave-breaking, which exhibit new blowup phenomena. Some wave-breaking conditons on the initial data are provided. In addition, this equation is known to admit single and multi-peaked solitons, of a different character than those of the Camassa-Holm equation. We will prove that the shapes of these waves are stable under small perturbations in the energy space.

Biography

Professor Qu received his PhD from Lanzhou University and promoted to the full professor in Northwest University, China in 1997 where he was the Head of Department of Mathematics from 2002 to 2008. He is a professor in Ningbo University and a New Century Excellent Talent of China. His research areas include the relation between invariant geometric flow and integrable system, properties of symmetry, invariance, well-posedness and geometry of nonlinear PDE. He has more than 150 papers in leading journals on PDE, mathematical physics and nonlinear analysis.

He was awarded the National Science Fund for Distinguished Young Scholars and Special Government Allowances from the State Council of China.

The series expansions of the Ramanujan constant and their applications

Songliang Qiu

Zhejiang Sci-Tech University, China
sl_qiu@zstu.edu.cn

Friday 01:30–02:30 Lecture Hall, Zhejiang Sci-Tech University

Abstract

The Ramanujan constant $R(a,b) = -2\gamma - \psi(a) - \psi(b)$ and its special case $R(a) = R(a, 1-a)$, where ψ is the classical psi function, play a very important role in the study of the Gaussian hypergeometric functions $F(a,b;c;z)$ and the theory of Ramanujan's modular equations, as well as in some other fields of mathematics. We give several kinds of expansions of series for $R(a,c-a)$ and $R(a)$ for different applications. This also provides us very effective tools, techniques and methods to reveal properties of $R(a,b)$ and $R(a)$. By these series expansions, some monotonicity and convexity properties and several new asymptotically sharp bounds are derived for these two constants, many known results for them can be easily improved or reproved by much simpler methods, and as by-products, several identities and inequalities satisfied by the Riemann zeta function and its related special functions are obtained. As examples of applications of these series expansions for $R(a,c-a)$ and $R(a)$, we shall also show several significant asymptotic properties and asymptotically sharp bounds of the zero-balanced Gaussian hypergeometric functions $F(a,b;a+b;z)$, the generalized elliptic integral of the first kind $K_a(r)$ and the complete elliptic integral of the first kind.

Biography

Professor Qiu received his PhD from Hunan University and promoted to professor in Hangzhou Dianzi University. He is a professor in Zhejiang Sci-Tech University on quasiconformal mapping with applications, Ramanujan theory and special functions. He has more than 100 publications in leading mathematics journals.

He received the Second Prize of National Teaching Achievement Award, and twice the First Prize of Teaching Achievement Award of Zhejiang Province. He is the President of Zhejiang Province Applied Mathematical Society and was the President of Zhejiang Sci-Tech University from 2004 to 2016 and the team leader of education assessment of the Ministry of Education of China.

Friday Plenary Talks

Mathematical modelling of the cardio-respiratory system: challenges and opportunities

Alona Ben-Tal

Massey University, New Zealand
a.ben-tal@massey.ac.nz

Saturday 02:30–03:30 Lecture Hall, Zhejiang Sci-Tech University

Abstract

The cardio-respiratory system and the mechanisms controlling it are essential for survival. Using mathematical models for their study is challenging but can provide important insights that help optimize treatment of cardio-respiratory diseases. Like many other biological systems, the cardio-respiratory system has multiple mechanisms that achieve the same function and processes that occur over multiple scales (in both time and space). Arguably, models at different levels of description are needed for different purposes, but deciding what the right level is, involves some degree of subjectivity. This modelling dilemma will be illustrated by looking at two examples concerning the cardio-respiratory system. The first example will show how mathematical modelling led to new insights on the physiological significance of Respiratory Sinus Arrhythmia (a heart rate variability at the frequency of breathing). The second example will show how a new numerical method, based on an equation-free approach, can help us simplify the dynamics of a bursting neural network.

Biography

A senior lecturer at Massey University, Dr Alona Ben-Tal is a rising star in the area of physiological modelling. Her main area of research in recent years has been the cardio-respiratory system of mammals. She has developed simplified models of lung mechanics, gas exchange and neural control of breathing and studied different aspects of the integrated system. She has also studied the interactions between the heart and the lungs and contributed to a study of optimal nutritional intake of pregnant sheep and modelling high speed weighing systems.

Alona received her PhD in Mathematics from the University of Auckland in 2001 and Bachelor and Master degrees in Mechanical Engineering from Technion Israel Institute of Technology.

Saturday Plenary Talks

Big data: problems and practice

Zongben Xu

Xi'an Jiaotong University, China
zbxu@mail.xjtu.edu.cn

Saturday 08:30–09:30 Ball Room, West Lake Hillview Hotel

Abstract

Big data bring various new opportunities for social governance, management, business and research, but the technologies for analyzing and processing big data are still not well developed. The three main challenges can be identified: the broken of statistical foundation, the inadaptability of computing technologies and the difficulty of Real and False test. To develop new foundation and methodologies for big data analytics are therefore imperatively needed. The scientific focus should include rebuilt of statistical foundation, innovation of big data algorithms and establishment of new test of real and false. As an example, we report a practice of our group in establishment of a big data algorithm: distributed kernel regression. A very typical requirement for big data analytics is to perform learning in distributive way. This is motivated not only from the need of processing the data stored in different physical sites but also pressed for possibility of copying with the data sets which are huge-sized, and it is prohibited to process in centralized manner. In such scenarios, an optimization/learning problem associated with entire data is expected to be solved through splitting it into a number of local problems associated only with partial or local data first, and then aggregating the local solutions to obtain the final estimator. We introduce a communication-efficient distributed kernel regression methods within the framework of ADMM (Alternating Direction Method of Multipliers) and regularized learning. We show that under mild conditions the introduced methods can achieve the mini-max optimal statistical performance as that when all data accessible if T rounds of communication are allowed, where

$$T = \log(m)$$

and m is the number of local machines/problems. The theory established is without restriction on number m of local machines and therefore is of particular interests for the applications in Internet of Things, where the computing units/local machines (say, mobile devices are worked both as information acquisitors and as computing units) are assumed huge. We provide extensive simulation and application examples with Spark platform to demonstrate the effectiveness of the new method.

Biography

Professor Zongben Xu received his PhD degree from Xi'an Jiaotong University in 1987 where he was promoted to a full professor in 1990. His research interests are in Banach spatial geometry theory and intelligent information processing. His work includes $L^{1/2}$ regularization theory for sparse microwave imaging, Xu-Roach Theorem in machine learning, new modelling and algorithms in visual cognition, and clustering, discriminant and latent viable analysis. He has more than 360 publications and he is an editor of 10 journals.

Prof Xu is an academician of the Chinese Academy of Sciences. He received the National Natural Science Award of China and CSIAM Su Buchin Applied Mathematics Prize. He was a 45-minute invited speaker at ICM 2010. He serves as a chief scientist of the 973 Project "The Basic Theory and Key Technology of Intelligence for Unstructured Environment" and Beijing Center for Mathematics and Information Interdisciplinary Sciences. He is a member of Academic Degree Commission of the Chinese Council, the National Committee for NSF of China, Guidance Expert Group for "Basic Research for Trusted Software", Tian Yuan Foundation Leading Group of the National Committee for NSF of China. He is also the group leader of Applied Mathematics Discipline Fund Review, the director of Teaching Guidance Committee for Mathematics Education and the Vice-Director of the Chinese Industrial and Applied Mathematics Commission.

Applications of nonclassical symmetries of partial differential equations

Philip Broadbridge

La Trobe University
p.broadbridge@latrobe.edu.au

Saturday 09:30–10:30 Ball Room, West Lake Hillview Hotel

Abstract

The 1969 paper by Bluman and Cole stimulated a lot of research on invariant solutions that could not be recovered from Lie's classical method. Only a special class of reaction-diffusion equations has full nonclassical reductions to solutions that are not invariant under classical symmetries. However some of those equations have important applications. For $1+1$ dimensional linear diffusion with a nonlinear reaction, only equations such as the Fitzhugh Nagumo equation, and the Huxley equation, with cubic source terms, have strictly nonclassical invariant solutions. Under the assumptions set down by Fisher in 1930, the advance of a new advantageous gene through a diploid population, is governed not by Fisher's equation but by Huxley's equation. For nonlinear reaction-diffusion equations in two spatial dimensions, there is a single restriction relating nonlinear diffusivity to nonlinear reaction, that always allows nonclassical reduction to Laplace's equation. This allows us to construct a large class of unsteady solutions to a reaction-diffusion equation with Arrhenius reaction term, that follows from the Gibbs non-analytic temperature-dependent probability distribution.

Biography

Professor Phil Broadbridge rejoined La Trobe in 2009 as Head of the School of Engineering and Mathematical Sciences. From 2005 to 2009, he was Director and CEO of the Australian Mathematical Sciences Institute and in that capacity was presented with the 2008 Fast Thinking/ Open Universities National Innovation Award in the category of science innovation. He was previously a professor of applied mathematics for 14 years, including a total of 8 years as department chair at the University of Delaware and at the University of Wollongong, where he was also Deputy Chair of Academic Senate. Having worked also as a secondary teacher and as a CSIRO researcher, he has strong interests in education and in industry outreach. He is particularly interested in the links between engineering and mathematics, and was part of the original writing team that secured HEIF funding for SMART Infrastructure at the University of Wollongong.

His PhD was in mathematical physics (University of Adelaide). He has an unusually broad range of research interests, including fundamental physics, applied nonlinear partial differential equations, hydrology, heat and mass transport and population genetics. He has published two books and over 100 refereed papers, appearing in 30 different scientific journals. He is a member of the editorial boards of two book series and three journals, including Proceedings of the Royal Society of London. He has been Editor-in-Chief of the US-based journal, Mathematical and Computer Modelling, as well President of Australia New Zealand Industrial and Applied Mathematics, the main professional association of applied mathematicians in Australia and New Zealand.

A new unique continuation for the Lamé equation

Jin Cheng

Shanghai University of Finance and Economy & Fudan University
jcheng@fudan.edu.cn

Sunday 11:00–12:00 Ball Room, West Lake Hillview Hotel

Abstract

The unique continuation property means that the solution of the partial differential equations on the small domain can determine the solution on the large connected domain. This is useful for study of inverse problems for partial differential equations. In this talk, we discuss the problems of determining the solutions of the Lamé equation from the partial information of the solution on the small domain.

Biography

Professor Jin Cheng received his Bachelor, Master and PhD degrees in mathematics from Fudan University, where he was promoted to the full professor in 2001. His research interests are in inverse problems for boundary value problems with PDEs and in numerical differentiation. He is in the editorial boards of Inverse Problems; Journal of Inverse and Ill-posed Problems; Math-in-Industry, Case Study; Journal of Math for Industry.

Prof Cheng is the Vice-President of Chinese Mathematical Society (CMS), the Executive Director of China Society for Industrial and Applied Mathematics (CSIAM), a Fellow of Institute of Physics, UK, a member of Steering Committee of Inverse Problems International Association and a member of experts team of the NSFC Major Research Plan (2011-2019) on fundamental algorithms and computable modelling of high-performance scientific computing.

01:30–02:00 **A finite difference method on graded meshes for a time-fractional diffusion equation**

Martin Stynes, Eugene O'Riordan and Jose Luis Gracia*

Beijing Computational Science Research Center

A reaction-diffusion problem with a Caputo time derivative of order $\delta \in (0,1)$ is considered. The solution of such a problem is shown in general to have a weak singularity near the initial time $t = 0$, and sharp pointwise bounds on certain derivatives of this solution are derived. A new analysis of a standard finite difference method for the problem is given, taking into account this initial singularity. This analysis encompasses both uniform meshes and meshes that are graded in time, and includes new stability and consistency bounds. The final convergence result shows clearly how the regularity of the solution and the grading of the mesh affect the order of convergence of the difference scheme, so one can choose an optimal mesh grading. Numerical results are presented that confirm the sharpness of the error analysis.

02:00–02:30 **Slip sliding away: how a small bubble in water slips along a hydrophilic surface**

Steven Carnie

The University of Melbourne

When a bubble immersed in water rests underneath a hydrophilic surface, it is separated from the surface by a thin liquid film of around 20-50 nm thickness, caused by repulsive surface forces. When the surface is inclined with a small angle, the bubble translates in steady motion along the surface, stabilised by a film subject to both hydrodynamic and surface forces. We have analysed this problem in recent years using various approaches. We developed asymptotic results (with L.R.White) for the steady drag assuming the flattened bubble profile is barely perturbed by the motion - a zeroth order theory. We then used numerical results using lubrication theory (the Reynolds equation) to compute the film profile and film drag, at first for a two-dimensional bubble, mainly to develop the algorithm but also to compare with scaling results of Hodges et.al.(2004) which have been developed for both two- and three-dimensional bubbles (and drops). We have some early numerical results for three-dimensional bubbles, which show the limits of our asymptotic results and existing scaling theory.

02:30–03:00 **Needlet approximation for isotropic random fields on the sphere**

Quoc T. Le Gia, Ian H. Sloan, Yu Guang Wang and Robert S. Womersley*

The University of New South Wales, Australia and La Trobe University

Isotropic random fields on the sphere have application in environmental models and astrophysics. In this work with Quoc T. Le Gia, Ian Sloan and Rob Womersley, we establish a multiscale approximation for random fields on the sphere using spherical needlets — a class of spherical wavelets. We prove that the semidiscrete needlet decomposition converges in mean and pointwise senses for weakly isotropic random fields on $\mathbb{S}^d$, $d \geq 2$. For numerical implementation, we construct a fully discrete needlet approximation of a smooth 2-weakly isotropic random field on $\mathbb{S}^d$ and prove that the approximation error for fully discrete needlets has the same convergence order as that for semidiscrete needlets. Numerical examples are carried out for fully discrete needlet approximations of Gaussian random fields.

03:00–03:30 **Afternoon tea**

03:30–04:00 **Modelling steaming Surtseyan ejecta**

Mark McGuinness , Emma Greenbank, Ian Schipper and Andrew Fowler*

Victoria University of Wellington

A Surtseyan bomb is a lump of very hot magma that trails steam behind it when erupted from a volcano. These bombs are observed alongside cocks tails and cypress tree-like steam and magma emissions that are also features of volcanic eruptions where magma interacts with lots of water.

Surtseyan ejecta are formed in shallow sub-aqueous eruptions. They occur when a combination of liquid water and sediments penetrates into molten magma during an eruption, and is then ejected from the volcano as an inclusion inside a ball of magma. After ejection there is a large temperature gradient between magma and inclusion. As the temperature of the inclusion increases, the liquid water vaporises causing a pressure increase inside the ejected ball.

The volcanological question is whether the ball of magma ruptures. Simple lumped calculations indicate the steam pressures could far exceed the tensile strength of rock. However, there is evidence of intact ejecta so we know that rupture does not always occur. Hence a more careful modelling approach is needed to explain and inform observations.

We present partial differential equations that model transient changes in temperature and pressure in Surtseyan ejecta. These equations are solved numerically and asymptotically to derive a parametric condition for rupture of ejecta. Steam escape times are also computed.

The above modelling, which was the subject of a talk at the ANZIAM meeting earlier this year, assumes that temperature and pressure are decoupled. We describe an extension of this model that allows for the fact that pressure and temperature are in fact coupled - this is work in progress.

04:00–04:30 **Image inpainting from partial noisy data by directional complex tight framelets**

Yi Shen , Bin Han and Elena Braverman*

Zhejiang Sci-Tech University, University of Alberta and The University of Calgary

Image inpainting methods recover true images from partial noisy observations. Natural images usually have two layers consisting of cartoons and textures, methods using simultaneous cartoon and texture inpainting are popular in the literature by using two combined tight frames: one (often built from wavelets, curvelets or shearlets) provides sparse representations for cartoons, and the other (often built from discrete cosine transform) offers sparse approximation for textures. Inspired by recent development on directional tensor product complex tight framelets (TP-$\mathbb{C}$TFs) and their impressive performance for the image denoising problem, this paper proposes an iterative thresholding algorithm using tight frames derived from TP-$\mathbb{C}$TFs for the image inpainting problem. The tight frame TP-$\mathbb{C}$TF$_6$ contains two class of framelets, one is good for cartoons and the other is good for textures. Therefore, it can handle both the cartoons and textures well. For the image inpainting problem with additive zero-mean i.i.d. Gaussian noise, our proposed algorithm does not require to manually tune parameters for reasonably good performance. Experimental results show that our proposed algorithm performs comparably and often better than several well-known frame systems for the image inpainting problem.

04:30–05:00 **Approximate controllability of population dynamics with size-Dependence and spatial distribution**

Shu-Ping Wang and Ze-Rong He

Hangzhou Dianzi University

This article investigates the approximate controllability of a size- and space-structured population model, the control function acts on a sub-domain and corresponds to the migration of individuals. We establish the main result via the unique continuation property of the adjoint system. The desired controller is the minimizer of an infinite dimensional optimization problem.

08:30–09:00 **The Lambert W function in optimization**

Scott Lindstrom and Jonathan Borwein*

The University of Newcastle

The Lambert W function is the inverse, properly defined, of $x \to x * \exp(x)$. Its role in convex analysis and optimization is under-appreciated. I will provide a basic overview of the convex analysis of W and go on to explore its role in duality theory where it appears quite naturally in the closed forms of the convex conjugates for certain functions. I will demonstrate a numerical approach for solving some examples, obtaining illustrative primal solutions which model the importance of checking solutions through more than purely symbolic means.

This is a joint work with Jonathan Borwein [1].

[1] Jonathan Borwein and Scott Lindstrom, "The Lambert W function in Optimization" available at `https://www.carma.newcastle.edu.au/jon/WinOpt.pdf`.

09:00–09:30 **A semi-analytic evaluation of finite maturity stock loans under a regime-switching economy**

Xiaoping Lu and Endah Putri*

University of Wollongong

In this work, we study finite maturity stock loans under a two-state regime-switching economy. The mechanism of standard stock loans resembles that of American call options with more complicated features, such as a negative interest rate and a time-dependent strike price. As a result, we first develop a semi-analytic approach based on the Laplace transform method for the evaluation of American options under a two-state regime-switching economy, then apply the approach to the corresponding stock loan problem. Two highly non-linear equations for calculating the optimal exit prices are obtained analytically in Laplace space. Numerical procedures are applied to solve the equations in the Laplace space and to invert the results back to the original time space. Examples are presented to validate our approach, as well as to show the effect of the regime-switching economy on the optimal exit price and the value of the stock loan.

09:30–10:00 **Pricing perpetual timer option under the stochastic volatility model of Hull-White**

*Jichao Zhang, Xiaoping Lu and Yuecai Han**

Jilin University and University of Wollongong

This report discusses the valuation of perpetual timer options under the Hull-White stochastic volatility model. By exploring the connection between Hull-White model and Bessel process and using time-change techniques, the triple joint distribution for the instantaneous volatility, cumulative reciprocal volatility and the cumulative realized variance is obtained. An explicit analytic solution for the price of perpetual timer call options is derived as a Black-Scholes-Merton type formula.

10:00–10:30 **Morning tea**

10:30–11:00 **A note on Markovian quantum dynamics**

*Liang Chen, Huixian Meng and Huaixin Cao**

Shaanxi Normal University

In this note, based on the divisibility denition of quantum Markovianity, the Markovianity of tensor products, multiplications, convex combinations of Markovian quantum dynamics are discussed. For example, it is proved that the tensor product of two Markovian dynamics is also a Markovian dynamics. Lastly, a new witness of non-Markovianity is proposed.

11:00–11:30 **Triangulation and complex geometry**

Simon Williams and William Moran*

Flinders University

The determination of position using three bearing measurements is studied from the perspective of information geometry. The differences between measurements on the plane and the sphere are explored.

11:30–12:00 **Size effect of a lipid pool inside of an atheroma lesion on the vulnerability of the plaque failure**

Colin Chen, Yan Ding , John A. Gear and Yuqing Feng*

RMIT University

This research is a part of our ongoing research project: Mathematical and computational modelling of atherosclerosis-atheroma lesion formation, growth and rupture. Atherosclerosis is a medical terminology meaning artery hardening. It is resulted by the presence of fatty deposits building up inside the artery to form a lipid pool of different sizes, thickening the artery wall and narrowing the passageway for blood flow. Atherosclerosis is the main contributor to myocardial and cerebral infarctions. According to the fact sheet No.317 of the World Health Organisation (WHO), released in March 2013, cardio vascular diseases, mainly from heart disease and stroke, have become the first leading cause of death globally and the number of death will reach 23.3 million by year 2030. This study focuses on the effect of the lipid pool size on (1) stress-strain distributions and variations in the plaque and diseased artery wall; (2) the disturbance to the blood flow downstream during a pulsatile heartbeat cycle. This is a numerical investigation using the two-way fluid-structural interaction (FSI) algorithm on an advanced 79% stenosis severity model representing the critical phase of atherosclerosis, beyond which the plaque failure is imminent due to either internal rupture of the plaque or external burst of the artery bulge at the site of atherosclerosis. Both small lipid pool and large lipid pool cases are considered, with different material properties assigned for the artery wall, fibrous cap and lipid pool of the plaque. The FSI simulation results show that the size of a lipid pool embedded in an atherosclerotic plaque plays a vital role on the stress and strain levels within the stenosis region of the artery wall. The plaque with a larger lipid pool is shown to have much higher stress values within its fibrous cap, dramatically increasing the likelihood of the plaque rupture. The downstream blood flow disturbance during a heartbeat cycle is also investigated for both large and small lipid pool cases. It is found that the flow recirculation zone downstream occurs at the deceleration phase of the blood flow in a heartbeat cycle, and the softer stenosis model due to a large lipid pool absorbs more impact from the disturbed blood flow, resulting in a larger and a more prolonged recirculation zone downstream.

12:00–01:30 **Lunch**

01:30–02:00 **On the relation between trinomial lattice and explicit finite difference for a regime-switching model**

Xiangchen Zeng

University of Wollongong

It is well-known that in the Black-Scholes economy, the trinomial tree method and the explicit finite difference method are equivalent. However, as a simple extension from the Black-Scholes model, the equivalence under the regime-switching framework hasn't been discussed yet. In this talk, we present a new trinomial tree method for a general N-state regime-switching model which is proved to be a special case of the explicit finite difference method. Connection between the two numerical techniques is shown. In particular, the convergence rate of our trinomial tree method in the two-state case is proved to be of the same order as the one presented by Yuen and Yang.

02:00–02:30 **On the convergence of discrete processes with multiple independent variables**

Naoyuki Ishimura and Naohiro Yoshida*

Chuo University and Hitotsubashi University

We deal with discrete stochastic processes with two independent variables; one is the standard symmetric random walk and the other is the Poisson process. The convergence is analysed such that the symmetric random walk tends to the standard Brownian motion. We show that a discrete analogue of the Ito formula converges to the corresponding continuous formula.

02:30–03:00 **Learning gradients from nonidentical data**

Xue-Mei Dong

Zhejiang Gongshang University

Selecting important variables and estimating coordinate covariation have received considerable attention in the current big data deluge. Previous work showed that the gradient of the regression function can provide both information. In this paper, an algorithm to learn the gradient of the regression function is proposed for nonidentical data. Under some mild assumptions on data distribution and the model parameters, a result on learning rate is established.

03:00–03:30 **Afternoon tea**

03:30–04:00 **An alternative method of concept learning**

Sen Wang , Qingxiang Fang and Jun-e Feng*

Shandong University and China Jiliang University

The problem of concept learning is solved using semi-tensor product method. All possible hypotheses are expressed under the framework of semi-tensor product. An algorithm is raised to derive the version space. In some cases the new approach improves the efficiency compared to previous approach.

04:00–04:30 **On exchange rate control using continuous and impulse stochastic controls**

*G. Bertola, W. J. Runggalider and K. Yasuda**

Chuo University

It is well-known that in the Black-Scholes economy, the trinomial tree method and the explicit finite difference method are equivalent. However, as a simple extension from the Black-Scholes model, the equivalence under the regime-switching framework hasn't been discussed yet. In this talk, we present a new trinomial tree method for a general N-state regime-switching model which is proved to be a special case of the explicit finite difference method. Connection between the two numerical techniques is shown. In particular, the convergence rate of our trinomial tree method in the two-state case is proved to be of the same order as the one presented by Yuen and Yang.

04:30–05:00 **Option pricing and volatility estimation in jump-diffusion models: a Mellin transform approach**

Marianito Rodrigo

University of Wollongong Australia

We use Mellin transforms to derive alternative results for option pricing and implied volatility estimation when the underlying asset price is governed by jump-diffusion dynamics. The current well-known results are restrictive since the jump is assumed to follow a predetermined distribution (e.g. lognormal or double exponential). However, the results we present are general since we do not specify a particular jump-diffusion model within the derivations. In particular, we construct and derive an exact solution to the option pricing problem in a general jump-diffusion framework via Mellin transforms. This approach of Mellin transforms is further extended to derive a Dupire-like partial integro-differential equation, which ultimately yields an implied volatility estimator for assets subjected to instantaneous jumps in the price. Numerical simulations are provided to show the accuracy of the estimator. This is joint work with T. Ray Li.

Author Index