Number 122 December 2014

NEWSLETTER

OF THE

NEW ZEALAND MATHEMATICAL SOCIETY

Contents

PUBLISHER'S NOTICE

This newsletter is the official organ of the New Zealand Mathematical Society Inc. This issue was edited by Mark C. Wilson with paid proofreader assistance. Editorial enquiries and items for submission to this journal should be submitted as plain text or LaTeX files to mcw@cs.auckland.ac.nz with "NZMS newsletter" in the title of the email.

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ISSN 0110-0025

EDITORIAL

This issue marks the end of the venerable Centrefold feature. However it has been reborn with a different name (Profile). This allays concerns by some members about the appropriateness of the name, and allows the Editor to place it anywhere, easing the task of layout. Now that so few paper copies are distributed, this extra flexibility will probably lead to better overall production quality. There are currently no Profile articles in the pipeline, so I urge anyone wanting to produce one to contact me as soon as possible. In particular, some members have asked that we provide more female subjects for these articles.

The theme of diversity features in the President's Report and in the report on the symposium inspired by Maryam Mirzakhani's Fields' Medal. Comparing old and new issues of this newsletter makes it clear that there are far more women contributing to mathematics at a high level in New Zealand than ever before. Nevertheless there is still room for improvement. I would like to hear from contributors with ideas for a census of women's participation in mathematics in NZ (suggested by Vivien Kirk).

A new feature (suggested by Gaven Martin) lists abstracts of NZ PhD theses in mathematics (broadly interpreted). This issue includes several such abstracts. In future we will probably reduce the word limit somewhat. Local correspondents have been asked to remind members to contribute these abstracts, but anyone can send them. We hope to have complete coverage as soon as possible, but this relies on contributions from the students and their supervisors.

We continue to present invited articles by NZMS prizewinners, this time Charles Semple and Florian Beyer. The backlog of these is almost cleared.

Cybermath is taking a break this issue (the author pleads exhaustion).

We continue the Interview feature, this time with repeat visitors Rosemary Bailey and Peter Cameron. Suggestions for interviews in 2015 are welcome.

The Events section is noticeably larger than usual. We have an extended personal report about ICM2014 from Hinke Osinga, among other items.

Book reviews are an important feature of this newsletter, and we have none in this issue. As always, such a newsletter can only work if there is a constant stream of interesting content. I urge members to suggest books for review, and to provide reviews, to the book review editor Bruce van Brunt.

As another busy year winds down, I wish all readers a satisfying and relaxing break.

Mark C. Wilson

PRESIDENT'S COLUMN

There are a number of recent achievements to be celebrated. In August, at the International Mathematical Union General Assembly, Vaughan Jones was elected IMU Vice President. In October, Iain Raeburn was elected a Fellow of the Royal Society of New Zealand. In November, Geoff Whittle was awarded a James Cook Fellowship. At the RSNZ Research Honours Dinner, two former NZMS Presidents received medals: David Vere-Jones was awarded the Jones medal and Marston Conder was awarded the Hector medal. Congratulations to all.

I had the privilege of attending the International Mathematical Union General Assembly and the International Congress of Mathematicians in the Republic of Korea during August. The International Mathematical Union General Assembly gathers delegates of IMU member countries, the IMU Executive Committee and other representatives. There were reports on activities, elections and resolutions. Papua New Guinea and Senegal were elected Associate members of the International Mathematical Union. A committee relating to Women in Mathematics is being created within the IMU and an internet site has been created at http://www.mathunion.org/wim. It was apparent from discussions that many efforts were being made within the IMU to advance this important issue. In addition a further resolution was adopted at the meeting to promote diversity.

At the ICM, there were a marvellous range of talks and posters, with participants from all around the world. The presentation of awards on the first day, including the four Fields Medals, had quite an air of excitement. These important awards were made by the President of the Republic of Korea. Overall there was a great atmosphere that reflected the generous (and huge) effort made by the Koreans. The four-yearly ICM is thoroughly recommended to any mathematician who has the opportunity to attend. The next ICM is in Rio de Janeiro in 2018.

I am delighted that Ingrid Daubechies of Duke University, the previous IMU President, has accepted the invitation to come to New Zealand as the 2015 AMS-NZMS Maclaurin Lecturer. I am also pleased to announce that the NZMS has a new Women in Mathematics page on its internet site. Please see http://nzmathsoc.org.nz/?wim. At the present time I am looking forward to the NZMS Colloquium within the joint Australia New Zealand Mathematics Convention in Melbourne.

Winston Sweatman

INVITED ARTICLES

Budgeted Nature Reserve Selection Problem

In conservation biology, measures such as phylogenetic diversity are used to quantify the biological diversity of a collection of species. These measures are used to select which species should be conserved and, in this regard, individual species are often the focus of attention. However, as pointed out by Rodrigues et al. (2005), this is not necessarily the best way to conserve diversity:

> Although conservation action is frequently targeted toward single species, the most effective way of preserving overall species diversity is by conserving viable populations in their natural habitats, often by designating networks of protected areas.

Motivated by this quote and applications of using phylogenetic diversity across areas to make assessments in conservation planning (Moritz and Faith 1998; Rodrigues and Gaston 2002; Smith et al. 2000), Magnus Bordewich and I investigated a computational problem arising in the context of conserving whole habitats instead of individual species (Bordewich and Semple 2008; Bordewich and Semple 2012). This article explains the problem and our solution to it.

Throughout the article, X denotes a finite set and represents a collection of species. A *rooted phylogenetic X-tree* $\mathscr{T}$ is a rooted tree with no degree-two vertices, except the root which may have degree two, and whose leaf set is X. Here, $\mathscr{T}$ describes the evolutionary history of a collection X of present-day species with time moving away from the root. Additionally, the edges of $\mathscr{T}$ are assigned non-negative real-valued lengths. The length of each edge is a relative measure of the number of mutations occurring along that edge. There are a number of different measures for quantifying the biodiversity of a collection of species. One of the most prominent is phylogenetic diversity and this dates back to Faith (1992). This measure is based on the evolutionary distance among the species in the collection. More particularly, let Y be a subset of X. The *phylogenetic diversity* (PD) of Y on $\mathscr{T}$ is the sum of the edge lengths of the minimal subtree of $\mathscr{T}$ connecting the leaves in Y and the root of $\mathscr{T}$. In its most straightforward application to conservation, the task is to find, for a given rooted phylogenetic X-tree $\mathscr{T}$ and a positive integer k, a subset of X of size k that maximises the PD score on $\mathscr{T}$ among all subsets of X of size k. Surprisingly, it turns out that a greedy algorithm solves the task exactly (Faith 1992; Pardi and Goldman 2005; Steel 2005). In Bordewich and Semple (2008), Magnus and I considered the following problem. In addition to $\mathscr{T}$, we have a collection $\mathscr{R}$ of regions or areas containing species in X. Each $R \in \mathscr{R}$ is a subset of X and has an associated cost $c(R)$ of preservation. Overriding these costs is a fixed budget B where, without loss of generality, we may assume that $c(R) \leq B$ for all $R \in \mathscr{R}$. The *Budgeted Nature Reserve Selection* (BNRS) problem is to find a subset $\mathscr{R}'$ of the regions in $\mathscr{R}$ that maximises the PD score of $\bigcup_{R\in\mathscr{R}}$ on $\mathscr{T}$ while keeping within budget, that is, subject to the constraint

$$\sum_{R\in\mathscr{R}'} c(R) \leq B.$$

The above mentioned applications to conservation planning are BNRS with unit costs. BNRS is NP-hard even with unit costs (Moulton et al. 2007). Nevertheless, the main result in Bordewich and Semple (2008) shows there is a polynomial-time approximation algorithm for BNRS.

Theorem 1. *There is a polynomial-time* $\left(1-\frac{1}{e}\right)$*-approximation algorithm for* BNRS. *Moreover, for any* $\delta > 0$*,* BNRS *cannot be approximated with an approximation ratio of* $\left(1-\frac{1}{e}+\delta\right)$ *unless* P=NP.

In other words, there exists a polynomial-time algorithm that returns a feasible solution to BNRS whose PD score is at least $1-\frac{1}{e}$ (roughly 0.63) times the the optimal score. BNRS is somewhat simplistic. For example, it is unrealistic to expect that because a species is not contained in at least one of the selected regions for preservation, its probability of survival is zero, or that its probability of survival is one if it is contained in one of the selected regions. In Bordewich and Semple (2012), we extended BNRS to allow for the following three inclusions:

(i) The first inclusion allows for arbitrary survival probabilities with the probability of survival increasing if it is contained in a region selected for preservation. Formally, each species $x \in X$ has probability $a(x,R)$ of surviving in region R without conservation efforts, but this probability is boosted to $b(x,R) \geq a(x,R)$ if R is selected for preservation. If x is not present in R, then $a(x,R) = b(x,R) = 0$. For a subset $\mathscr{R}'$ of regions, we denote by $p_{\mathscr{R}'}(x)$ the probability that x survives in at least one region, where survival in each region R is independent and has probability $a(x,R)$ if $R \notin \mathscr{R}'$ and $b(x,R)$ if $R \in \mathscr{R}'$.

(ii) Evolutionary relationships are not necessarily described by a single tree. The relationships may be more accurately described by a collection of gene trees (each representing the tree-like evolution of a gene or a group of genes) rather than a single species tree. The second inclusion allows for PD to be scored across a set of weighted trees on the same leaf set X of species. That is, we extend $\mathscr{T}$ to a collection $\mathscr{P} = \{\mathscr{T}_1, \mathscr{T}_2, \ldots, \mathscr{T}_k\}$ of rooted phylogenetic X-trees, where each $T_j \in \mathscr{P}$ is assigned a non-negative real-valued weight $w(T_j)$. The *phylogenetic diversity* of a subset of X on $\mathscr{P}$ is the weighted sum of the PD measured against each tree in $\mathscr{P}$.

(iii) Under PD, one assumes that features arise during evolution at a constant rate and persist to be present in all descendant species. Thus, for each time step, a new feature arises. For the third inclusion, we extend this model so that, in addition to features arising in this way, features have a constant probability of disappearing on every evolutionary path in $\mathscr{T}$ in which they are present. Mathematically, features disappear independently on each edge according to an exponential distribution with rate λ, that is, once a feature is present, it has a constant and memoryless probability $e^{-\lambda}$ of surviving in each time step.

With these three inclusions, what is the function we are trying to optimise? For each $x \in X$, let the probability of survival be denoted by $p(x)$. Under this extended model, the *phylogenetic diversity* of X on $\mathscr{T}$, denoted $PD_{(\lambda,\mathscr{T})}(X,p)$, is the expected number of features present amongst the surviving species. That is,

$$PD_{(\lambda,\mathscr{T})}(X,p) = \int_{t\in\mathscr{T}} \mathbb{P}(t \to X)dt,$$

where $(t \to X)$ denotes the event that a feature arising at point t on $\mathscr{T}$ survives to be present in a species in X which itself survives. Extending to a collection $\mathscr{P} = \{\mathscr{T}_1, \mathscr{T}_2, \ldots, \mathscr{T}_k\}$ of weighted rooted phylogenetic X-trees, the *phylogenetic diversity* of X on $\mathscr{P}$, denoted $PD_{(\lambda,\mathscr{P})}(X,p)$, is

$$PD_{(\lambda,\mathscr{P})}(X,p) = \sum_{j=1}^{k} w(\mathscr{T}_j) \int_{t\in\mathscr{T}_j} \mathbb{P}(t \to X)dt.$$

Allowing for all three inclusions, extends BNRS to the following problem:

Problem: Budgeted Nature Reserve Selection (BNRS$_{(\lambda,\mathscr{P})}$)
Instance: A collection $\mathscr{P}$ of weighted rooted phylogenetic X-trees, a collection $\mathscr{R}$ of subsets of X, a cost function c on the sets in $\mathscr{R}$, a budget B and, for all $(x,R) \in X \times \mathscr{R}$, probabilities $a(x,R)$ and $b(x,R)$ with $b(x,R) \geq a(x,R)$.
Task: Find a subset $\mathscr{R}'$ of $\mathscr{R}$ that maximises $PD_{(\lambda,\mathscr{P})}(X, p_{\mathscr{R}'})$ subject to the constraint

$$\sum_{R\in\mathscr{R}'} c(R) \leq B.$$

Despite the extent of the generalisation that comes with the additional inclusions, we established the following theorem in Bordewich and Semple (2012).

Theorem 2. *There is a polynomial-time* $\left(1-\frac{1}{e}\right)$*-approximation algorithm for* BNRS$_{(\lambda,\mathscr{P})}$.

In terms of a polynomial-time approximation algorithm, we can't do any better unless P=NP as BNRS is a special instance of BNRS$_{(\lambda,\mathscr{P})}$. The key to proving Theorem 2 is realising that

$$PD_{(\lambda,\mathscr{P})} : 2^{\mathscr{R}} \to \mathbb{R}^{\geq 0}$$

is a non-negative, non-decreasing, submodular function which is computable in polynomial time. With this realisation, one is then able to apply a result of Sviridenko (2004) to establish the theorem. Of course, as Theorem 1 is a corollary of Theorem 2, we could have taken the same approach to proving Theorem 1 but we were naive at the time and proved it directly.

It is natural and practical to consider the unrooted analogue of BNRS$_{(\lambda,\mathscr{P})}$. In Bordewich and Semple (2012), we did this allowing for the unrooted analogue of inclusion (ii), but not (i) and (iii). Inclusion (iii) inherently requires a direction corresponding to time and unrooted phylogenetic trees have no such direction, but we could allow for varying probabilities of survival, that is, inclusion (ii). However, the approach we used for establishing Theorem 2 does not go through. It remains an open problem to determine if such a polynomial-time approximation algorithm is possible.

Charles Semple

General relativity and PDEs

In Einstein's general relativity (GR), space and time constitute a dynamical "space-time continuum" in which our physical world takes place. The space-time geometry "interacts" with every material object – this is what we know as gravity – and this mutual interaction is described by *Einstein's equation* (EE). Mathematically, space-time is a smooth 4-dimensional manifold whose points are interpreted as "events". The space-time manifold carries a metric of Lorentzian signature, i.e., a non-definite (to reflect the different nature of time and space) but non-degenerate bilinear form which describes the geometry. GR is used to model our universe and hence to address the fundamental question: How did our universe "begin" at the "big bang" about 13 billion years ago? It also yields a description of astrophysical systems of stars and black holes and, in particular, of gravitational wave signals emitted by such. One expects that in the not so distant future, gravitational waves will play the same role for astronomical observations as light waves have ever since mankind started to observe the stars.

The dynamics of space-time turns out to be highly nontrivial even in "vacuum", i.e., without any matter. This is a consequence of the involved nonlinear nature of EE. Since *any* nontrivial geometric equation is nonlinear this is not a surprise, and nonlinear geometric evolution equations have become popular research topics in the field of PDEs. Examples are the mean-curvature flow, wave maps, and, in particular, the Ricci flow which led to the recent resolution of the *Poincaré conjecture* – one of the Millennium Prize Problems – and the Fields medal in 2010. EE is therefore only one, but a particularly important and difficult example of a geometric evolution equation. A first point to make is that for *suitable* coordinate conditions – here we restrict to so-called harmonic or wave coordinates – EE implies a system of quasilinear wave equations for the components of the metric with respect to the coordinates and is hence, at least regarding local properties, tractable by current PDE techniques. In fact, this coordinate condition was used by Yvonne Choquet-Bruhat in the 1950's to give the first proof of well-posedness of the Cauchy problem of EE – a result which is of fundamental importance because without well-posedness, GR could hardly be considered a "reasonable" physical theory!

Rigorous studies of *global* properties of solutions of nonlinear wave equations are in general difficult and are mostly beyond reach of current PDE techniques. In fact, singularities occur frequently in such solutions. In GR they often have physical meanings (black holes, big bangs, horizons etc.). In the case of Ricci flow the precise understanding of the resulting nonlinear heat equations and the occurrence of singularities was the key to the astonishing result above. It is therefore an important task to classify and describe singularities. For EE, a combination of numerics and rigorous analysis has led to some insights but many difficult open problems remain. Stephen Hawking and Roger Penrose proved a series of "singularity theorems" in the 1960's and 70's which apply to quite generic situations, but the relationship between the *asserted* "incompleteness" vs. the *expected* "geometric singularness" is still not clear. Because of this the so-called *BKL conjecture* (named after the Russian physicists Belinskii, Khalatnikov and Lifshitz) has emerged since the 1970's. According to this, a singularity in a general solution of EE is *spatially local* in the sense that any hypothetical observer who approaches such a singularity gets more and more isolated from the rest. Eventually, just before he/she is smashed by the singular gravitational field, he/she experiences a fully isolated homogeneous but highly dynamic cosmos. Formally, certain terms in EE are supposed to become negligible close to the singularity, and the equation, where these terms are dropped, therefore describes the effective dynamics. In comparison to the full EE this effective equation is simple (it is an *ordinary* DE), but the effective dynamics turns out to be complicated and, in general, oscillatory. Indeed, apart from special cases this has posed an unsolved obstacle, and one does not even know whether there *exist* solutions to EE which obey the general dynamics predicted by BKL. However, it also turns out that the effective dynamics can be *non-oscillatory* in some cases. In the terminology of Eardley, Isenberg et al. such solutions of the full EE are called *asymptotically velocity term dominated*. The main first step towards the resolution of the outstanding BKL conjecture is therefore to rigorously prove the *existence* of such solutions.

The so-called *Fuchsian method* is a useful technique to tackle this problem. Instead of constructing solutions to the *Cauchy* problem, one envisions to solve an "initial value problem with singular data". In our case, these are data suggested by the effective equation. Until recently the Fuchsian method was limited to real-analytic solutions which is a genuine restriction as it rules out wave phenomena, in particular gravitational waves. It was mainly our contribution to overcome this restriction in a series of papers [1, 2, 3] and to prove well-posedness results for singular solutions of quasilinear hyperbolic PDEs in certain time-weighted Sobolev spaces; the result is thus not restricted to EE. The new idea of our proofs was to approximate the sought solutions given by *singular* data consistently by solutions of the *regular* Cauchy problem and then to use standard energy estimates for the Cauchy problem to control convergence. Ever since, the Fuchsian method has established quite large classes of solutions of EE which are compatible with the BKL conjecture in the non-oscillatory case. My collaborators and I have mainly focussed on pushing existing results beyond the real-analytic setting. In particular, real-analyticity singles out special coordinates, but since the BKL conjecture is by definition coordinate dependent, such results are only

meaningful geometrically if they extend to larger classes of coordinates. We are currently writing up a paper about so-called asymptotic wave coordinates. On the other hand, we are the first to use Fuchsian methods to study the role of matter and the so-called "matter does not matter" hypothesis part of the BKL conjecture. It is interesting that this yields several borderline cases to which the current Fuchsian theorems do not apply but which may instead be studied by a new numerical approximation scheme suggested by our Fuchsian theory.

A full comprehension of singularities in GR is still out of reach but we are optimistic that this ongoing research, where restrictive assumptions are reduced step by step, will lead to a better mathematical and physical understanding of our physical world.

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Florian Beyer

MATHEMATICAL MINIATURE

MM35: Jam today in the Nic of time

There might have been mathematical enthusiasts who envied other parts of the world where the MathsJam activity has taken hold. Dr Nicolette Rattenbury was a member of the Manchester MathsJam but has now returned to New Zealand. I spoke to her recently about what she has been up to.

John B Good morning Nicolette. You were away from New Zealand several years and I am glad you are back now. What were you doing while you were away?

Nicolette R Good morning John. My husband and I moved to Manchester for him to take a postdoc at Jodrell Bank Observatory in Manchester. I finished writing up my PhD for the first year or so. I then started some part time lecturing at Manchester University and then got a lectureship in Mathematics at Manchester Metropolitan University. We were gone for just over 9 years. I have also managed to have 2 wonderful children in that time.

John Wow, that sounds like an exciting 9 years. How old are the children now?

Nicolette I have a son who is 6 years old and a daughter who is 16 months old.

John Were you able to keep up with research when you were at Manchester Metropolitan University? It must have been difficult to fit everything into your life. Or was this mainly a teaching position?

Nicolette Yes, it was mainly teaching. I was involved in courses from foundation year to final year. It was a wonderful university to be at. The staff were great to work with and the students worked really hard. I was also involved in quite a bit of outreach work, which I found really rewarding. I did do a bit of research but only little bits here and there.

John I heard about something you have brought back with you from the UK. It's called MathsJam. Is that right? What's all this about?

Nicolette MathsJam started up in London in 2008. It very quickly spread to a few other cities in the UK, Manchester being one of them. I attended the Manchester MathsJam on a regular basis. I really enjoyed it and thought it was time MathsJam made its New Zealand debut. I believe there are MathsJams in 38 cities all around the world now. It really is just a chance for self-confessed Maths enthusiasts to get together at the pub and talk about all things Maths.

John What is a typical activity at these MathsJams?

Nicolette We do all sorts: mathematical origami, puzzles, talk about Maths that is in the news, talk about our favourite mathematical ideas and play mathematical games (SET is a particular favourite).

John What is SET?

Nicolette SET is a card game, which is very simple to play. Each card in the pack has 4 attributes : colour, shape, number of objects and shading. A SET is three cards that are either all the same or all different in each individual attribute. Twelve cards are laid out. The first person to call SET wins that group of cards. The play continues until the deck is finished. It is highly addictive!

John Who can take part? Is it only for professional mathematicians? If someone turned up who loved mathematics but wasn't sure how he or she would measure up, would this person be welcome?

Nicolette It is for absolutely anyone who is interested in mathematics. We have teachers, students, lecturers as well as people who have nothing to do with mathematics in their work life.

John Is this the only MathsJam in NZ?

Nicolette No, one has now started up in Wellington.

John Can you tell me, for the readers, how to get in touch with either the Auckland or Wellington MathsJam?

Nicolette Auckland MathsJam can be contacted on auckland@mathsjam.com. Not surprisingly, Wellington can be contacted on wellington@mathsjam.com.

John Do you have any interesting MathsJam questions which will intrigue the readers of this column?

Nicolette Here is one that comes originally from Leeds MathsJam. There are a set of chameleons, 13 red, 15 blue and 17 green. When two chameleons of different colours meet, they both change to the third colour (when two chameleons of the same colour meet, nothing happens). The question is, can they ever all become the same colour?

John That sounds difficult. Do the MathsJam members work on this sort of problem together or they go home and think about it and report back at a later meeting when they have an answer?

Nicolette We tend to all work on the problems together. Having said that there have been problems which we have discussed via email later, as we haven't managed to solve them on the night.

John By telling me this question, it also becomes a problem for Mathematical Miniatures readers. I will certainly print the best answer I receive in the next MM. Do any other interesting questions come to mind?

Nicolette You have 12 marbles, one of them is either heavier or lighter than the rest. In 3 weighs on a balance scale, how can you find the odd marble and also tell if it's heavy or light?

John This really is an old one but a good one. I remember it from the 1950s. With three weighings, each of which has 3 possible outcomes it should be possible to distinguish between $3^3 = 27$ possibilities. But there are only 24 possible answers in your question. I think it also works if there is also the possibility that all the marbles are the correct weight. Do you have anything else to offer?

Nicolette How about a Christmas greeting to sign off

$$\frac{(90-C_1)(90-C_2)\cdots(90-C_n)}{2u}$$

John That sounds like another puzzle for our readers to decipher. Thanks Nicolette for talking to me so eloquently and persuasively about the pleasures of MathsJam.

Let me now recall a problem from MM34: How can you make sure you never lose the following game: the numbers $0, 1, \ldots, 8$ are available to be selected and retained by each of two players who choose in turn. Because there are only 9 numbers to choose from, there cannot be more than 5 moves. One of the players has won the game if, at any stage, exactly three of the numbers chosen by this player have a total value of 12. For example, if the first six numbers chosen are 5, 0, 1, 6, 4, 3, so that player A owns the numbers 5, 1 and 4; while player B owns 0, 6, 3. But it is now A's turn and a winning move is to select 7. Player A now owns 5, 1, 4 and 7 and the last three of these add up to 12. The winning strategy is well-known for the isomorphic game of noughts and crosses, or tic-tac-toe. The isomorphism is based on the magic square on the left and the more traditional square on the right, where the winning total is now 15.

1	8	3
6	4	2
5	0	7

2	9	4
7	5	3
6	1	8

J. C. Butcher

INTERVIEWS

Rosemary Bailey (interviewed by Dimitri Leemans)

Dimitri First of all thank you very much Rosemary for agreeing to be interviewed for the New Zealand Mathematical Society Newsletter. You have spent almost two months at The University of Auckland thanks to a Hood Fellowship and you are about to head back to Scotland.
Was mathematics part of your familial activities when you were a child?

Rosemary Well, my mother taught me to count and she taught me my tables. I, in turn, taught my brother who's eleven years younger. When he was learning his numbers, he had his black board in the back garden and he went from ten down to one. I taught him zero and I thought about teaching negative numbers but my mother came running out in the garden to tell me off, but yes, we were expected to be numerate.

Dimitri And how did you decide to study mathematics?

Rosemary Because it was the only thing I couldn't bear to give up. So at age fifteen in the UK, you had to specialize in just three subjects. I said "I don't want to specialize in three" because if you did maths you did two. So I did maths and physics and I said I wanted to do geology as well. And then when it came to be time to apply to go to university, I applied to some places to do mathematics and some to do geology. And I had an interview at the University of Nottingham and they said "look, do your maths degree first, you can change to geology later." So I thought I'd do that and by the time I'd actually done a degree in mathematics I was hooked.

Dimitri You did your PhD in Oxford on group theory. Why did you decide to switch to statistics?

Rosemary Well, there's two things. In the British system, if you went to Oxford or Cambridge you did your normal two years ASIC form and then you had a term when you did the exams for Oxford and Cambridge and then you had nine months which nowadays would be like a gap. You had nine months to do something else. And the something else I did through the father of a schoolmate of mine, I got a job working in medical research in air pollution. So I was a technician and I helped gather the data. I had no training but I got an exposure to statistics that way and so I always had that interest. And then I did my PhD in group theory. I had a job. It wasn't terribly interesting. One day there was this advert in a paper from the University of Edinburgh. They said "we have this problem in designing experiments where to know about randomization you would have to know about group theory. We have this postdoctoral position. Ideally we would want someone who knows group theory and statistics but we don't realistically expect to get someone like that. If we have someone with the group theory knowledge, we could retrain them." So I applied for that and I got it.

Dimitri And you were not tempted at some point to switch more to industry with your statistical background?

Rosemary No, I think not. So I finished my postdoc and I went back to the Open University where I had been. But the way I learned about design of experiments was via agricultural research and that was done in the public sector in the UK at a place called Rothamsted and so at a certain point I saw an opening at Rothamsted and I thought I'd just go there two years to get practical experience and I stayed for ten. And the thing that actually made me leave was at a certain point they reorganised the agricultural research council and they said there's two marches of this blue sky research we want to concentrate more on the market. By that time I decided that the market and industry/private companies was not the way I wanted to go and in fact, if you came to my public lecture, you'd have heard me ranting on about doing experiments for the good of humanity, so things like improving food supplies, improving medicine and that's what drives me.

Dimitri Did your knowledge in pure mathematics help you in your statistical career?

Rosemary It did but only by being bloody minded. So I was using group theory, finite fields, things like that in parts of statistics where typically people aren't educated in those things. For example, I've talked to a statistician here who said that she regrets that she did not learn those things as an undergraduate because she was focussing on statistics. So that helped me but on the other hand it meant that when I was submitting papers I could meet resistance so I just had to persevere. But it is still there. A PhD student of mine submitted what I thought was a really useful paper about designs for clinical trials and she had made her designs by using group theory and the journal concerns said "this is a statistics journal, we don't want any group theory!"

Dimitri You started your career at a time when women in mathematics, and more generally in the academic world, were not legions. Did you encounter problems that you think were linked to the fact that you are a woman? And if yes, how did you overcome these problems?

Rosemary Well, it never occurred to me at first that there would be a problem. And then, when I had my first job interview right after my PhD, people on the other side of the interview table were all men and they said to

me "surely it would be more suitable for you to become a school teacher because then when your husband moves you can easily move with him." These days you wouldn't be allowed to say things like that. I don't remember what I said but I got the job and the fact is that that has now changed.

Dimitri So you think these matters are better nowadays?

Rosemary Yes. They don't make that assumption anymore . . . I hope.

Dimitri What are your future plans?

Rosemary I hope I can continue proving theorems because I just keep finding more and more interesting problems and I keep working on them.

Dimitri What do you think are the big problems nowadays in your area of statistics?

Rosemary I don't know. I am not very good on big questions. But something I've been working on for a few year now, again it was something I said in my public lecture. We used to take it as absolutely a given that when you do an experiment, your treatments are replicated as equally as possible and that would make the variance more . . . And then it was shown that when the blocks have size 2, and the replication is low, that's not true and that was very shocking. And we now know that it's true for all block sizes and there's a sort of phase change and I've been working on that because even though there are proofs down there, there are still people who don't believe it. Something I saw recently was: let's take the best design possible for these treatment factors and then see how to put them into blocks. What I'm saying is that may not give you the best design whereas if you knew from the start that you had to put them into blocks . . .

Dimitri Thank you very much for your time Rosemary. And all the best for the future!

Peter Cameron (interviewed by Dimitri Leemans)

Dimitri First of all thank you very much Peter for agreeing to be interviewed for the New Zealand Mathematical Society Newsletter. You have spent almost two months at The University of Auckland thanks to a Hood Fellowship and you are about to head back to Scotland.

Could you tell us a little bit about your early life? Were there any mathematical activities in your family in Toowoomba?

Peter I grew up on a dairy farm. When I was a child we were too far from the nearest school for me to go to school and there was no school bus so I learned at home for a few years. My mother had been a primary school teacher and she guided my studies. They also had material on the radio in those days so I got off to a good start, and when I went to school in fact they had to put me up a class because I'd learned so much at home. Neither of my parents were mathematicians in any sense but my father had studied engineering at university before circumstances brought him back to the dairy farm. So he was always ready to encourage me to do mathematical things. He introduced me to the problem of the grains of wheat on a chessboard at quite an early age. I had already thought enough about it that I said you have to add up these powers of two. He said "well there's a quicker way" and I said "yes I know, I've already figured it out!"

Dimitri Where did you study for your undergraduate degree?

Peter I was at the University of Queensland from 1964 to 1967 and as was common in those days there was a three-years pass degree or a four-years honour's degree and I was so sure that I wanted to be a mathematician that I immediately started on the four-years degree. The mathematics department, unlike most of the other departments there, put on special classes for the honours students, different from what the pass students got. I got a very good and broad education in mathematics over a wide range of areas, not just my speciality which was, I suppose, algebra in those days.

Dimitri How did you decide to go to Oxford?

Peter I got a Rhodes scholarship. I did not have any choice in the matter. The only choice was which college to go to and I picked that more or less at random.

Dimitri What impression did it make on you coming from Australia over 40 years ago?

Peter Things were a bit different. The weather mainly. It was very difficult having to go for months at a time without seeing the sun. Oxford is a very damp, foggy place. But I got on well there. I was supervised by Peter Neumann. He was an ideal supervisor for me because he was full of ideas but he wouldn't force any of them upon me so he gave me plenty to think about and I would go and think about those things.

Dimitri Your whole career has been in the UK although you've maintained close ties with Australasia. What is your impression of the health of the mathematical discipline in Australia and in New Zealand?

Peter I've been in Australia and New Zealand several times in recent years and I think that Mathematics there is facing the same problems as in many other countries. Mostly we are expected to produce results with short term applications and actually contribute to economic growth and stuff like that, but this is not how the best mathematics is done – as we know – and we have to keep fighting for proper funding for mathematics

without necessarily a view to applications out of it. It is no less true for the fact that it's just been said many times that mathematics underpins pretty much everything in our technological society, and it's crucially important to have mathematicians continue to do that. Now, in Australia and New Zealand, mathematicians have managed to continue doing this despite the pressures of funding and various other things. I am hopeful that this can continue and that governments will not be so short-sighted that they will completely close this down but we have to keep watching.

Dimitri Your blog "Cameron counts" has related your adventures with the administration of Queen Mary. Do you think it is exceptional in its bureaucratic approach or that the whole UK academic sector is heading that way? It seems much worse than what we are familiar with here in New Zealand.

Peter I think there's a general trend in the UK universities to go in this direction. The typical thing that happens is that a university vice-chancellor says "we want to be a leading university, so how do we do that? We look at our competitors and copy them." If our competitors all do something then we have to do that as well, even if we have a different system that works perfectly well for us. This is quite a common thing. In particular, how do they judge our teaching and research? Teaching and research are the things that we do in a mathematics department. Now research is judged by how many grants you get. Teaching is judged by the student evaluations. Neither of these are good measures. Once you set up a measure people aim for that rather that aiming for doing good teaching and research. So it is self-destructive in the end. Some UK universities have gone further down that track than others and Queen Mary particularly has gone a long way in that direction with the new principal. I found since I've been in St Andrews that there, they are much less far down the track and they still believe in the fact that we are there to do teaching and research and they try to make it possible for us to do that.

Dimitri What are your future plans?

Peter I absolutely have no intention of retiring. In fact it used to be the case that you had to retire at 65 in the UK. I was the first cohort to which that rule does not apply and even though I decided to retire from Queen Mary just to get out of the bureaucracy, when St Andrews came along with an offer for a half-time job, that was absolutely ideal for me. I certainly intend to go on proving theorems and now that I am only working half time I will have more time to be even more productive. I believe that I started off my semi-retirement in a very good way. I had lots of trips this year and I got a lot of research done with many different people on different continents and this is absolutely how I wanted to be and I certainly intend to continue that.

Dimitri What do you think are the big questions in combinatorics and group theory today?

Peter Well, if you had asked me this a year ago, I would have said one of the big questions in combinatorics is the existence of t-designs for large t. This has now been spectacularly settled by Peter Keevash. The point is that his methods suggest that different strands of combinatorics that have been done by people working in entirely different traditions can come together to produce new big results; but if I had to pick one problem that we really really don't understand, it would be the existence of projective planes. Do they necessarily have prime power order? Or are there planes with non-prime power order? Nobody has much of an idea how to solve that problem. Perhaps out of the blue a spectacular breakthrough will come along and solve that question.

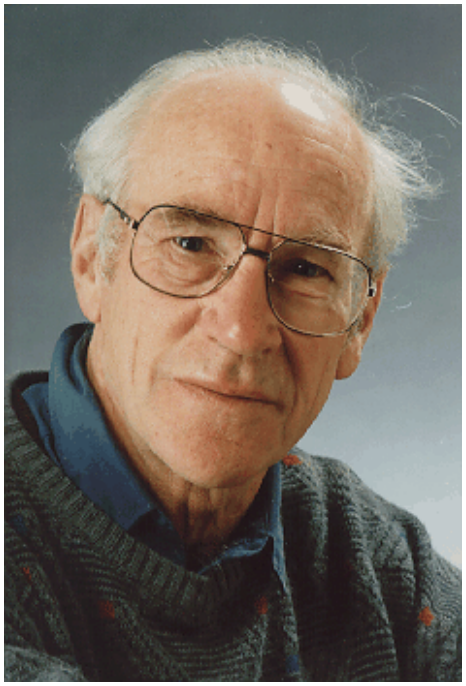
Dimitri What would you say to people who say that combinatorics is something you can do while waiting for your bus?

Peter I believe any subject of mathematics is something you can do while waiting for your bus. At a certain point you have to sit down and write the calculations down on paper, check them and check all the arguments carefully but mathematics is a subject that we do in our heads and particularly, in the back of our heads while we're doing something else, waiting for a bus or going for a walk or sleeping or whatever. We are constantly processing and pushing forward mathematics. Combinatorics has taken a lot of flak because it is a subject that is broad rather than deep. Nobody could prove something like the Riemann hypothesis in combinatorics. There are no comparable questions but the best results in combinatorics produce unexpected links between entirely different-looking parts of the subject and the insight to do that could happen to you just as easily while you are waiting for the bus as anywhere else. I think that anyone who says that combinatorics is not really mathematics ignores the fact that almost every great mathematician has used combinatorial arguments in at least part of their work, has sometimes even explicitly acknowledged that. So, for example, Roger Lyndon, a group theorist, was asked in an interview what he thought was the common feature in his best work and he said "combinatorics."

Dimitri Thank you very much for your time Peter and all the best for the future!

PROFILE

David Vere-Jones



Professor David Vere-Jones has been awarded the prestigious Vaughan Jones Medal for 2014 by the Royal Society of NZ. Awarded biennially, this is the third award. He received it in person at the Science Honours Dinner in Wellington on 26th November.

David Vere-Jones is New Zealand's leading resident mathematical statistician. He has made major contributions to the theory of probability and statistics, their applications, and to the teaching of statistics and mathematics in New Zealand. He is highly regarded internationally, and has received numerous invitations to overseas institutions and conferences over the course of his long and distinguished career. He has well over 150 refereed publications. Professor Vere-Jones has received numerous honours and distinctions. In 1995 he was awarded the International Statistical Institute Henri Willem Methorst Medal, and in 1999 he received the NZ Science and Technology Gold ('Rutherford') Medal. He was elected as a Fellow of the Royal Society of New Zealand in 1982. He has been an ordinary elected member of the International Statistical Institute since 1978 and a Fellow of the Royal Statistical Society since 1969.

Research

His research areas have been concerned with Point Processes (the statistical theory of sequences of events that occur at discrete points in time or space, such as earthquakes, neuron firings, volcanic eruptions, etc.) and Markov Processes (including branching processes and queuing theory). A substantial body of theory owes its origins to him, either directly or via his students. Of particular importance and relevance to New Zealand is his pioneering work on the applications of point process theory to seismology. He received the International Journal of Forecasting Prize in 1997 for the best article in the preceding 5 years for his 1995 paper "Forecasting earthquakes and earthquake risk". He obtained Marsden grants (as principal investigator) on the projects "Non-linear modelling of fracture mechanisms" (1997–1999), "Statistical models for the approach to criticality in earthquake occurrence" (2001–2003), and "Hidden Markov models for earthquake processes with ancillary measurements" (2005–2009).

Contributions to Mathematical Sciences Education in New Zealand

Professor Vere-Jones has made substantial contributions to mathematical and statistical education in New Zealand. He was the Subject Convener for Mathematics for the University Entrance Board of the University

Grants Committee (1978–85) and chaired the Education Committee in the Royal Society of New Zealand (1987–90). He was instrumental in setting up Victoria University's Institute of Statistics and Operations Research in 1975, which promoted and coordinated research, teaching and consulting in those fields.

Professional Associations

Professor Vere-Jones is a former president of the NZ Mathematical Society (1974), which he helped found, and a former president of the NZ Statistical Association (1981–83). He was Chairman (in the 1980s) of the East Asian and Pacific Regional Committee of the Bernoulli Society (a branch of the International Statistical Institute). He was Interim President (1991–92) of the International Association for Statistical Education, which took over the role of the International Statistical Institute Education Committee which he chaired from 1987.

Professor Vere-Jones was a key member of a team responsible for writing a major review of the mathematical sciences for the Ministry of Research, Science and Technology. As Professor Jeffrey Hunter (review chair) wrote in the preface to their 1988 report, *Mathematics in New Zealand: Past, Present and Future*, "I wish to express my debt of gratitude to Professor David Vere-Jones who has borne the brunt of the writing of the final report. Without his efforts and dedication this project would have faltered."

A Short History

David Vere-Jones was born in London but came to New Zealand at the age of twelve. He studied at Victoria University of Wellington in the mid-fifties, and then won a Rhodes scholarship to undertake postgraduate research in probability theory at Oxford, supervised by Professor D. G. Kendall. After completing his doctorate he went, as an exchange Scholar, to Moscow University where he made contact with the strong Russian school on probability and, in particular, Professor Boris Gnedenko. These contacts led to life-long mathematical links and friendships. His two papers on non-negative matrices, although developed as part of Markov chain theory, are relevant to areas of mathematics quite unrelated to statistics. David returned to Wellington in 1962 and took up the post at the Applied Mathematics Laboratory of D.S.I.R. which he held until the mid-sixties. After short appointments at the Australian National University, Michigan State University and Manchester University, the call to Wellington was again answered by his appointment, in 1970, to the chair of mathematics at Victoria University. Under David's leadership, the group in statistics and operations research (latterly to become the Institute of Statistics and Operations Research) built up a strong national and international reputation in research, teaching and consulting. In 1988 he authored (with Dr D. J. Daley) an influential reference book *The Theory of Stochastic Point processes*. This was revised, extended and updated in 2002 and 2007. The resulting books An Introduction to the Theory of Point Processes (Volumes I and II) are the pre-eminent reference texts in the subject.

David "retired" from the Victoria University of Wellington in 2000, becoming Professor Emeritus. He remained an active researcher, founding Statistics Research Associates Limited in 1999 (with Dr R. B. Davies and Dr P. J. Thomson) and was a director of this company until 2009. Under its auspices, David led a number of successful research projects on earthquake risk modelling with funding from the Marsden fund, the Institute of Geological and Nuclear Sciences (an ongoing involvement) and the NZ Earthquake Commission. He was Director of a research programme funded by the New Zealand Institute of Mathematics and its Applications on Hidden Markov Models and Complex Systems. In 2005 David was a joint author and reviewer for the Statistical Society of Australia sponsored review Statistics at Australian Universities with Professor A. F. M. Smith (Queen Mary College, London) and Professor L. R. James (Murdoch University, Western Australia). This review has been influential in both Australia and New Zealand. David has also played a leading role in setting up an annual series of Statistical Seismology workshops with the first in China (hosted by the China State Seismological Bureau) and the second timed to coincide with his Festschrift on the occasion of his 65th birthday in 2001. These workshops continue to be held and have helped the formation of Statistical Seismology as a sub-discipline in its own right. He now lives on the Kapiti Coast north of Wellington, his wife Mary having died some years ago. They have three adult children and grandchildren. Many of us can attest to the kindness and generosity of spirit David extends to all with whom he has contact.

The Mathematical Sciences community is glad to applaud the award of this top award to one of our most famous and distinguished sons.

(This is based on the nomination statement for the award. I thank its author for permission to use it.)

Graeme Wake

LOCAL NEWS

ANZIAM

The NZ branch of ANZIAM has expressed its support for a pilot MISG-style NZ Industrial Mathematics Initiative in a letter to Dr Bram Smith the General Manager of KiwiNet. MISG (Mathematics in Industry Study Group) is an annual meeting that brings together academics and industry representatives to tackle complex technical problems facing the industry. The AustraliaNew Zealand MISG was inaugurated in 1993 and since then was held in NZ three times: from 2004 to 2006 inclusive. Although MISG has been very successful, NZ companies seem to be increasingly reluctant to participate in MISG events when the meetings are held offshore while at the same time there seems to be an under-utilised pool of potential participants within NZ. KiwiNet (a consortium of Universities and Crown Research Institutes) is interested in supporting the introduction of a NZ based industrial maths initiative, similar to the MISG approach and has already commissioned a scoping report on initiatives taken in other countries. It is envisioned that the pilot MISG-style NZ Initiative will begin in mid-2015 (likely to be 29 June to 3 July, 2015) and would be in synergy with the present ANZIAM MISG. Professor *Graeme Wake*, a previous Director of the ANZIAM MISG and a strong advocate for the new initiative says that the NZ MISG-style pilot is also supported by Te Pūnaha Matatini (a newly funded Centre of Research Excellence).

Alona Ben-Tal

AUCKLAND UNIVERSITY OF TECHNOLOGY

SCHOOL OF COMPUTING AND MATHEMATICAL SCIENCES

Events

On 17 September *Sergiy Klymchuk* organised an official launch of the STEM Tertiary Education Centre (www.stemtec.aut.ac.nz) of which he is Founding Director. The Centre was formally opened by the Minister Steven Joyce. The launch was widely publicised on Maori and Chinese TV programmes and several radio stations including Newstalk ZB. The Centre has partnerships with 15 national and international centres on mathematics and science education including Community for Undergraduate Learning in the Mathematical Sciences (CULMS), University of Auckland and Technology, Environmental, Mathematics and Science Education Research Centre (TEMS), University of Waikato.

In the beginning of November Sergiy hosted *Zbigniew Michalewicz*, Professor of Computer Science at University of Adelaide, who is internationally regarded as a creator and promoter of puzzle-based learning methodology (www.puzzlebasedlearning.edu.au/) through his books "Puzzle-Based Learning: An introduction to critical thinking, mathematics, and problem solving" and "A Guide to Teaching Puzzle-based Learning". Zbigniew gave a series of seminars at AUT on puzzle-based learning and teaching, academia and entrepreneurship, and evolutionary computations

On 27–28 November, the Mathematical Science Research Group (MSRG) successfully organised its inaugural symposium: The 2014 AUT Mathematical Sciences Symposium. This was a joint effort of *Jiling Cao* and *Jeffrey Hunter*, with the assistance of *Kate Lee*, *Sarah Marshall* and *Katharina Parry*. The Symposium attracted over 40 participants from some NZ and overseas Universities, with 32 talks including 8 plenary ones. The symposium focused mainly on some areas in Applied Mathematics and Analytics/Statistics. This main purpose of this event is to develop and promote opportunities for AUT academic staff working on these areas to collaborate with colleagues from other universities.

In October, *Seth George Hall* and *Bing (Frank) Huang* successfully defended their PhD theses. The title of Bing's PhD thesis is "Real Option Games with Stochastic Volatility", supervised by Jiling Cao and Hyuck Chung, and the title of Seth's PhD thesis is "GPU Accelerated Feature Algorithms for Mobile Augmented Reality", supervised by Andrew Ensor and Roy Davies. The two candidates were awarded PhDs subject to amendments.

Travel and Conference Participation

Wenjun Zhang was awarded one AUT contestable conference grant to attend the 8th International Conference On Applied Mathematics, Simulation, Modelling in Florence, Italy from 22–24 November 2014.

Jiling Cao

UNIVERSITY OF AUCKLAND

DEPARTMENT OF MATHEMATICS

Bill Barton was a member of the Plenary Panel on "Mathematics Education Open Online Courses" at ICM in Seoul on August 1, and he was also a member of the Invited Panel on "How To Teach Better".

Graham Donovan has received a Marsden Fast-Start Award, for "Mathematical dynamics of asthmatic clustered ventilation defects". *Arkadii Slinko* won a Marsden award for "Axioms and algorithms for design of multi–winner elections" (with Mark Wilson and Geoffrey Pritchard - *Ed.*). *David Gauld* comments

about the Marsden awards that "Over the years I have been keeping track of our Marsden awards. I think that my numbers are more-or-less right. This year was the 20th year of the awards, and over those 20 years we have received a total of 51 awards totalling a bit over $17 million. There have been 4 awards under $100,000 and a similar number over $600,000. Our best year in terms of numbers was 1998 when we received 7 awards (but the next year we got none, as also happened in 2008). We don't seem to have done quite as well in the 10 rounds since 2005 as the first 10: a bit over $8 million for 18 awards in the past 10, compared with a little over $9 million for 33 awards the first 10 years."

Jaqueline Field has accepted a permanent appointment to the Tertiary Foundation Certificate programme, joining Rachel Passmore and Phil Kane in delivery of this programme. Jac's appointment will commence on January 19, 2015, and she will continue in her current "Certificate in Academic Preparation" role until Nov 30, 2014. We have already advertised to fill the resulting vacancy in that programme.

Steven Galbraith has been selected by the London Mathematical Society and NZMS to be the initial Aitken lecturer, to tour the UK in October 2015.

Vaughan Jones has been elected as Vice-President of the International Mathematical Union (IMU) for the next 4 years. This is a high distinction, never achieved previously by anyone from Australia or New Zealand. The IMU is a member of the International Council for Science (ICSU), which met at Auckland in August. The IMU was established to promote international cooperation in mathematics, and to encourage and support other activities that contribute to the development of pure, applied and educational aspects of the mathematical sciences. Vaughan will serve as Vice-President until the next International Congress of Mathematicians in 2018 (in Brazil).

Ben Martin left the department in October, to take up a position as Reader at the University of Aberdeen. He has been a valued colleague and he will be much missed.

Greg Oates was the coordinator (with *Tanya Evans*, *Sina Greenwood*, *Garry Nathan* and *Julia Novak*) of our Department's application (together with the Department of Statistics and Student Learning Services) to the Vice-Chancellor's Strategic Development Fund, entitled "Mathematical Preparedness in The Quantitative Sciences". That application was accepted, gaining a grant of $85,000, and it will run during 2015.

Hinke Osinga gave an invited lecture at the ICM in August. She is only the 4th New Zealand-based mathematician to be invited to speak at ICM.

Mirko Wojnowski has accepted a permanent appointment to the "Certificate in Academic Preparation" programme, and he will take up this role on December 1.

Dr *Tim Burness*, Senior Lecturer at the University of Bristol, is the recipient of the inaugural "Kalman Visiting Fellowship". This Fellowship, funded by the Kalman Foundation, supports generously a visit by a "rising star" in mathematical sciences to the University of Auckland. The selection committee consisted of the following: Professor Robert MacCulloch (trustee of Kalman Foundation), Marston Conder (Vice-Chancellor's Representative), James Sneyd (Dean of Science Representative) and Eamonn O'Brien (Head of Department of Mathematics).

Afshin Mardani submitted his thesis, and his PhD has now been approved.

The New Zealand Mathematics and Statistics Postgraduate Conference 2014 was held in November at Whitianga, and *Abshishek Bhardwaj* won a prize for his talk there.

Recent visitors include Prof. Astrid an Huef (University of Otago), Prof. Peter Ashwin (University of Exeter), Dr Boris Baeumer (University of Otago), Prof. Rosemary A. Bailey (University of St Andrews), Prof. Peter Cameron (University of St Andrews). Prof. Freddy Dumortier (Hasselt University, Belgium), Dr *Joanna Fawcett* (UWA), Dr Janne Koponen (University of Eastern Finland), Prof. Diana Lambdin (Indiana University, Bloomington), Dr Emanuele Latini (Universität Zürich), Prof. Charles Leedham-Green (Queen Mary University, London), Prof. Mariusz Lemanczyk (Nicolaus Copernicus University in Torun), Prof. Frank Lester (Indiana University, Bloomington), Dr Luke Morgan (UWA), Prof. Vladimir Muller (Czech Academy of Science, Prague), Prof. Cheryl E. Praeger (UWA), Prof. Mick Roberts (Massey University, Albany), Dr Renate Scheidler (University of Calgary), Prof. Mariel Vazquez (UC Davis), Prof. Andrew Waldron (UC Davis), Dr Arjana Žitnik (University of Ljubljana) and Prof. Dr Kang Zuo (Universität Mainz).

Garry J. Tee

UNIVERSITY OF WAIKATO

DEPARTMENT OF MATHEMATICS

Congratulations to *Liam McMahon* for being a runner-up in the University of Waikato "Three Minute Thesis" competition. Competitors had three minutes in which to explain the content of their PhD research work. This was the first time that there had been a winner from the Department of Mathematics and the first time since 2010 that the Faculty of Computing and Mathematical Sciences has had a winner in the competition.

Liam's presentation was titled "Mathematics of Solar Flares" and he won $1500 for his effort. Liam's PhD supervisors are Yuri Litvinenko, Sean Oughton,

and Ian Craig. Liam has given a longer presentation at this year's New Zealand Mathematics and Statistics Postgraduate Conference. Also attending this conference were three other graduate students from the Department of Mathematics and the Department of Statistics. These students will be organising next year's event.

Early in the new year, *Reshma Ramadurai* will join the department for two years as a Research Fellow. She is currently working at the University of New South Wales. Her research interests are in combinatorics and discrete mathematics.

Stephen Joe

MASSEY UNIVERSITY

INSTITUTE FOR NATURAL AND MATHEMATICAL SCIENCES

In each of the last 4 years, mathematicians from Albany have taken part in an annual Forum "Maths-for-Industry" (FMI) organised by the Institute of Mathematics for Industry (IMI) at Kyushu University, Fukuoka, Japan (2011: Boris Pavlov; 2012: Robert McKibbin; 2013: Robert, Graeme Wake and Winston Sweatman). As a member of the IMI International Advisory Board (IMI-IAB) since 2013, *Robert McKibbin* attended this year's forum, FMI2014, held in Fukuoka in late October.

One of our recent PhD students *Nurul Syaza Abdul Latif*, now a Senior Lecturer in the University of Malaysia at Kelantan, won an award for her poster "Modelling Induced Resistance to Diseases in Plants" (such as PSA in Kiwifruit). *Luke Fullard* from Massey at Manawatu, was an Invited Speaker.

FMI2014 also included the launch of the Asia-Pacific Consortium of Mathematics for Industry (APCMfI), which aims to be a regional collaborative grouping of institutions that promote industrial mathematics (or more broadly, mathematics for industry): see https://apcmfi.org/. The Centre for Mathematics in Industry (CMI) based at Albany will be an active component of APCMfI.

Amjad Ali has successfully defended his PhD on modelling pollution transport in groundwater aquifers. Amjad was supervised by Robert McKibbin and Winston Sweatman. Amjad is now working as a Research Fellow for six months with Graeme Wake on commercial contract work for a company client in the agriculture services industry. Amjad expects to return to Pakistan in the first half of 2015, with a family that has been enlarged since he arrived in NZ (wife Sumaira and their baby boy Faris who was born earlier this year).

Ali Zaidi, another PhD student from Pakistan, was the winner of the award for the best talk in the Mathematics and Statistics Section of the Institute's Postgraduate Conference in October. He works on cell population dynamics, supervised by Graeme Wake and Bruce van-Brunt. *Andrea Babylon*, who works with Mick Roberts and Graeme Wake on disease modelling involving species interactions, took the second prize.

Dr *Haydn Cooper*, a PhD graduate from here who now works for IRD, is undertaking scoping work in preparation for the first Mathematics-in-Industry Initiative mentioned elsewhere in the ANZIAM NZ Branch news. This work is funded by KiwiNet which is a national consortium of universities and CRIs interfacing with industry groupings.

Winston Sweatman has been promoted to Associate Professor. Winston attended the European Conference for Mathematics in Industry in Taormina, Italy; was an invited speaker at the Irish European Study Group for Mathematics in Industry at University College Dublin; and attended the International Astronomical Union Symposium on Complex Planetary Systems in Namur, Belgium. In Edinburgh and Glasgow he met Scottish colleagues to discuss stellar dynamics. Winston was the New Zealand delegate to the International Mathematical Union General Assembly in Gyeongju. He presented a poster at the International Congress of Mathematicians in Seoul on the likelihood of full ionisation in binary star interactions.

Shaun Cooper

UNIVERSITY OF CANTERBURY

SCHOOL OF MATHEMATICS AND STATISTICS

Congratulations to *Phil Wilson* and *Miguel Moyers-Gonzalez* who have been awarded a $60,000 grant from the IBM Research Fund for their project proposal "Gone with the wind: pedestrian comfort, pollutant dispersion, and infrastructure resilience in the city".

Best wishes to *Alex James* on the birth of her son Seth Weston James, in August. *Clemency Montelle* and *Jeanette McLeod* persuaded School staff to turn their hands to crocheting peggy squares for Alex's son. The end result, stitched together beautifully by Jeanette, is displayed at the end of the Local News.

Callaghan Innovation's R&D Experience Grant was awarded to DataMine for research with *Raazesh Sainudiin* into conditional regression with specific deliverables of a set of high-level wrappers (in Python) for the library in C++ developed by Raaz and his collaborators. The library allows for an efficient arithmetic with plane binary trees for massive data problems in ways

that complement the state-of-the art dual-tree methods developed at Carnegie Mellon and Georgia Tech to take full advantage of all available Random Access Memory.

Dominic Lee, who has been working with the Wynyard Group on a one year appointment, has decided after much thought to resign from the University of Canterbury and stay with that company. The School is very sad to see Dominic leave. He has been with us for over ten years and he has contributed to the School, and particularly our research profile, in many ways. Dominic is very keen to continue working with us in his new role, with postgraduate students and other research projects.

Following Dominic's lead, *Raazesh Sainudiin* was granted leave of absence for 2015 to take up an opportunity with the Wynward Group. This is an exciting development for Raaz, and also for the School to further strengthen our connections with the company.

Douglas Bridges announced that he will be retiring next year in April after 16 years at the University of Canterbury.

Sarah Vincent has decided not to return to her position as administrative assistant after her maternity leave expired in August.

Congratulations to *Helen Rowley*, who has been appointed to the continuing position of School administrator. Helen had been in the School since May last year on a fixed-term contract.

In October the School welcomed *Daniel Gerhard* from Germany to take up his position as a statistical consultant/lecturer with a focus on Applied Statistics. Previously, he was a Postdoc at the Institute of Biostatistics at Leibniz University, Hanover, Germany, where he also finished his doctorate dealing with likelihood-based inference and multiplicity adjustment of simultaneous confidence intervals. Daniel is not a Statistician by training but, rather, educated in Horticulture where he discovered an interest in planning and analysing agricultural field trials. From there, he got more involved in Applied Statistics. His research interests cover a wide range from nonlinear and hierarchical modelling to model selection and simultaneous inference. Recently, he has been kept busy with dose-response analysis in the area of toxicology and biological sciences.

In late July the School welcomed Erskine Fellow *Alessandra Luati* and Oxford fellow *Helen Byrne*. Alessandra is from the University of Bologna, Italy. Her special fields of interest are Mathematical Statistics, Asymptotic Theory, Statistical Inference and Time Series Analysis. In addition to teaching in STAT213 (Statistical Inference), Alessandra also presented a couple of seminars. She was hosted during her 9 weeks visit by *Marco Reale*.

Helen is from the Oxford Centre for Collaborative Applied Mathematics (OCCAM), and her speciality is Dynamical Systems as applied to Biomathematics and modelling cancer growth. Helen lectured into EMTH171 (Mathematical Modelling and Computation), meeting with postgraduate students, and meeting with the Brains Trust: BlueFern Supercomputing Centre. Her principal host was *David Wall* during her 6 and a half weeks visit.

In September we welcomed Gary Froyland from the School of Mathematics and Statistics at the University of New South Wales, on an Erskine fellowship. Gary's fields of special interest are dynamical systems and ergodic theory with geophysical applications. Gary lectured into MATH363 (Dynamical Systems) and interacted with Honours and PhD students in seminars. the first week of his visit coincided with SON2014, for which he was one of the keynote speakers and also on the organising committee.

SON2014, the 5th International workshop on Set Oriented Numerics, was held in the School, September 1–5, and organised by *Rua Murray*. The workshop aimed to address state-of-the-art developments in the field of set-oriented numerical techniques relevant to mathematical problems in dynamical systems and applications. The SON workshops provide a unique forum to bring together theoretical researchers developing different set-oriented methodologies and applied researchers needing and/or using topological and probabilistic tools for analysing their models. The workshop will cover a wide range of application areas, including, but not limited to: models of fluid flow, advection-reaction-diffusion equations, biology, drug design, quasi-stationary stochastic processes, nonlinear time-series analysis, dynamics of granular material, physical oceanography and meteorology. With around 30 participants it was a vibrant and stimulating week.

The School hosted a two-day Canterbury statistics event on 12th and 13th November. The first day was the Canterbury Statistics Research Day with over 30 researchers from 8 different organisations meeting. Graham Wood (now with AgResearch) and Timo Teresvirta (Aarhus University, Denmark) were the key note speakers. The Canterbury Statistics Research Day was also supported by AgResearch. It is annual event showcasing statistics research in Canterbury.

The following day was the Canterbury Mathematics Teachers Day, organised by the Canterbury Mathematics Association, focusing on teaching statistics at high school level. We had 120 teachers on campus with the key note speaker Lillian Grace, Founder and CEO of Wiki New Zealand. The day saw a series of workshops for teachers, and two staff, *Marco Reale* and *Irene David*, were workshop presenters. Both days were coordinated by *Jennifer Brown* and *Michelle Dalrymple*, a recent visitor to the School.

In October, *Mike Steel* presented public lectures in Nelson, Queenstown and Wanaka, titled "Darwin's re-

gret – what maths can tell us about the evolution of life" The talks highlighted the way that mathematics helps in the study of evolution (with some practical demonstrations of stochastic processes, using coloured balls and breaking sticks) along with quotes from Charles Darwin showing how he wished he'd learned something more of the "great leading principles of mathematics". The talks were sponsored the Allan Wilson Centre, and organised locally by the Royal Society branches (the talk in Queenstown was held at the main high school and included teachers, pupils and members of the public).

Congratulations and best wishes for the future to *Abdul Haq*, who successfully defended his PhD thesis "Improvements in ranked set sampling" in September. His examiners were full of praise for the quality of his work and expressed the opinion that he had delivered more in just over two years than most candidates would in six. Included in the examiners' comments was the following: "At many academic institutions in the US, Mr Haq's body of work would be enough to warrant tenure and promotion". Abdul has already produced more than ten publications during his tenure as a doctoral student, with many more papers submitted or in preparation. Abdul was supervised by Jennifer Brown and Elena Moltchanova, and has returned to his native Pakistan.

Remediation work in the Erskine building is in its final stages and we are looking forward to getting our building back—without drilling noises, hammering, or the smell of paint solvent wafting through the corridors. Scaffolding in the atrium started to come down in mid November.

Günter Steinke

UNIVERSITY OF OTAGO

DEPARTMENT OF MATHEMATICS AND STATISTICS

After 39 years of service at the University of Otago, *Gerrard Liddell* retired this year. Gerrard was awarded a BSc(Hons) from the University of Canterbury and afterwards did a MSc and PhD at Queen's University in Canada. Back in New Zealand, he started as an Assistant Lecturer at the Department in 1975 to become a Lecturer three years later. His research was on quantum mechanics, algebraic computing, non-distributive logics and C^*-algebras. He was also interested in differential equations, modelling, the optimal trajectories of robot arms and measures of truth possession. Among his colleagues, Gerrard was always highly respected for his comprehensive knowledge of a broad spectrum of mathematics. Best wishes for a very happy retirement! But we are sure that we will regularly see you at the Department.

Tim Jowett has started his position as the Department's new statistical consultant. Tim was a masters student at Otago, and we are happy to have him back after he worked at Invermay AgResearch in Mosgiel for 18 months. He will provide statistical support and advice to staff members and postgraduate students around campus. Welcome (back), Tim!

We welcome *Michael Lee* and *Benoît Auvray*, who have taken up their positions as Senior Research fellows, and *Yuki Fujita*, our new Assistant Statistical Consultant.

Iain Raeburn is among the twelve top New Zealand researchers and scholars in basic and applied science and the humanities who have been elected as Fellows of the Royal Society of New Zealand in October. Congratulations, Iain!

Congratulations to *Boris Baeumer* and *Mihály Kovács*, *David Bryant*, and *Ting Wang* for being awarded Marsden grants in this year's Marsden Fund. Boris and Misi will study "Evolution equations with memory and random fluctuations", David (together with co-PI Steven Higgins from Botany) is looking at "The evolution of the functional diversity of forests", and the topic of Ting's Fast-Start grant is "Developing inversion methods for non-stationary thinning of point processes".

Visitors

Claus Hertling (University of Mannheim) and Christian Klein (Institut de Mathématiques de Bourgogne) visited the department for two weeks in August/September, hosted by *Jörg Frauendiener*. Claus gave a seminar on the "Geometry of the movable poles of real solutions of Painlevé III". Mike Whittaker (University of Wollongong) visited for one week in October. Mike was hosted by *Iain Raeburn*.

We also had a short-term visit by Alison Kohout (NIWA, Christchurch), who was hosted by *Fabien Montiel*. Alison is mainly doing field work to measure wave characteristics in the ice-covered Southern Ocean, and she provides modellers with experimental data for validation.

Jörg Hennig

Colleagues mentioned in Local News reports (left to right, top to bottom): the official launch of the STEM Tertiary Education Centre with (left to right) Charles Walker, Derek McCormack, Steven Joyce, Sergiy Klymchuk and Roy Nates; Daniel Gerhard; Gerrard Liddell; Seth Weston James and the quilt made for him by staff of the University of Canterbury School of Mathematics and Statistics; the staff with the quilt (right front row, left to right: Helen Rowley, Liz Ackerley, Irene David, Jeanette McLeod, Brendan Creutz, Hilary Seddon, Pauline Auger; second row: Günter Steinke, Steve Gourdie, Phillipa Williams, Mike Steel, David Wall, Marco Reale, Phil Wilson; third row: Chris Price, Mike Plank, Maarten McKubre-Jordens).

ABSTRACTS OF NZ PHD THESES

Abdul Haq, University of Canterbury

Supervisors: Jennifer Brown and Elena Moltchanova

Date: September 2014

Title: **Improvements in ranked set sampling**

The main focus of many agricultural, ecological and environmental studies is to develop well designed, cost-effective and efficient sampling designs. Ranked set sampling (RSS) is one of those sampling methods that can help accomplish such objectives by incorporating prior information and expert knowledge to the design. In this thesis, new RSS schemes are suggested for efficiently estimating the population mean. These sampling schemes can be used as cost-effective alternatives to the traditional simple random sampling (SRS) and RSS schemes. It is shown that the mean estimators under the proposed sampling schemes are at least as efficient as the mean estimator with SRS. We consider the best linear unbiased estimators (BLUEs) and the best linear invariant estimators (BLIEs) for the unknown parameters (location and scale) of a location-scale family of distributions under double RSS (DRSS) scheme. The BLUEs and BLIEs with DRSS are more precise than their counterparts based on SRS and RSS schemes. We also consider the BLUEs based on DRSS and ordered DRSS (ODRSS) schemes for the unknown parameters of a simple linear regression model using replicated observations. It turns out that, in terms of relative efficiencies, the BLUEs under ODRSS are better than the BLUEs with SRS, RSS, ordered RSS (ORSS) and DRSS schemes. Quality control charts are widely recognized for their potential to be a powerful process monitoring tool of the statistical process control. These control charts are frequently used in many industrial and service organizations to monitor in-control and out-of-control performances of a production or manufacturing process. The RSS schemes have had considerable attention in the construction of quality control charts. We propose new exponentially weighted moving average (EWMA) control charts for monitoring the process mean and the process dispersion based on the BLUEs obtained under ORSS and ODRSS schemes. We also suggest an improved maximum EWMA control chart for simultaneously monitoring the process mean and dispersion based on the BLUEs with ORSS scheme. The proposed EWMA control charts perform substantially better than their counterparts based on SRS and RSS schemes. Finally, some new EWMA charts are also suggested for monitoring the process dispersion using the best linear unbiased absolute estimators of the scale parameter under SRS and RSS schemes.

Christopher Laing, University of Otago

Supervisor: Jörg Frauendiener

Date: 2014

Title: **Numerical construction of static fluid interfaces with the embedding formalism**

This research project develops a mathematical and numerical framework for representing static fluid interfaces as embedded manifolds. A variational principle is developed for the embedding function of a smooth manifold, along with the necessary boundary and gauge conditions. The variational problem is solved by a combination of Finite Elements, constrained optimisation techniques, and original algorithms. The approach is applied to problems inspired by modern technological and scientific applications of static fluid interfaces, and the results are compared to exact solutions, experimental data, or other numerical methods, where possible. The impact of the numerical methods on the quality of the solution is discussed in detail, with reference to the boundary conditions, the gauge conditions, and the constraints.

Joshua Stewart Voorkamp, University of Otago

Supervisors: Mike Hendy, Barbara Holland and David Bryant

Date: 2014

Title: **Untangling evolution**

Molecular biology makes extensive use of methods that can accurately estimate the evolutionary relationships between species, particularly when the evolutionary history can be represented on an 'evolutionary tree'. However, attention is increasingly turning towards approaches that can be applied when the history might not be adequately represented by a tree. This thesis presents computational methods that work towards the goal of inferring an 'evolutionary network' directly from sequence data. The particular focus was on computational methods that are

'fit agnostic' which refers to the idea that any method for evaluating how well a structure matches provided data could be used in place of the one used here. Given the underlying mechanisms used the evaluation methods that do well will be those that preserve the relationship that if a particular tree gives a good fit to the data then restricting the tree and data to a subset of taxa will also give a good fit. The final goal of achieving a network was not reached as there remain some problems and no obvious way yet to solve them. As a temporary placeholder in order to ascertain if the methods *could* be applied to networks sets of evolutionary trees were used whereby the sets of evolutionary trees are to be interpreted as existing in some network which a future algorithm may work on directly. The methods and theory in this paper have thus been formulated so that there should be an analogue from these that are developed for sets of evolutionary trees to ones that can be applied to evolutionary networks.

Anuj Bhowmik, Auckland University of Technology

Supervisor: Jiling Cao

Date: April 2013

Title: **Blocking Efficiency and Competitive Equilibria in Economies with Asymmetric Information**

In this thesis, two most fundamental problems in economic theory, namely the existence and the optimality of Walrasian equilibrium, are studied. It is assumed that there is uncertainty about the realized state of nature in an economy and different agents may have different information. Such an economy is called an *economy with asymmetric information*. Considering a pure exchange asymmetric information economy with finitely many states of nature, an atomless measure space of agents and a Banach lattice as the commodity space, it is shown that the private core and the set of Walrasian allocations coincide. The feasibility in this result is taken as free disposal. This optimality is known as the core-Walras equivalence theorem. When the feasibility is defined without free disposal, then it is shown that if a feasible allocation is not in the private core then it is privately blocked by a coalition of any given measure less than that of the grand coalition. This theorem not only gives the full answer to a question in [72], but also provides a sharper characterization of Walrasian allocations.

In addition to the above optimality, some other characterizations of Walrasian allocations by the veto power of the grand coalition are also established. One of them deals with robustly efficient allocations in a pure exchange mixed economy with asymmetric information whose commodity space is an ordered separable Banach space having an interior point in its positive cone. This gives a solution to the question posed in [48]. Other two characterizations are restricted to a discrete economy with a Banach lattice as the commodity space. First one claims that a feasible allocation is a Walrasian allocation if and only if it is Aubin non-dominated, whereas the other one is interpreted in terms of privately non-dominated allocations in suitable associated economies. These yield a partial solution to a question in [41]. The feasibility in all of these results is defined as free disposal.

In a pure exchange asymmetric information economy whose space of agents is a finite measure space, space of states of nature is a probability space with a complete measure, and commodity space is defined as the Euclidean space, the existence of a maximin rational expectations equilibrium is established. So a solution to a question in [32] is obtained.

Seth George Hall, Auckland University of Technology

Supervisors: Andrew Ensor and Roy Davies

Date: October 2014

Title: **GPU Accelerated Feature Algorithms for Mobile Augmented Reality**

Mobile devices offer many new avenues for computer vision and in particular mobile augmented reality applications that have not been feasible with desktop computers. The motivation for this research is to improve mobile augmented reality applications so that natural features, instead of fiducial markers or pure location knowledge, can be used as anchor points for virtual mobile augmented reality models within the constraints imposed by current mobile technologies. This research focuses on the feasibility of GPU-based image analysis on current smart phone platforms. In particular it develops new GPU accelerated natural feature algorithms for object detection and tracking techniques on mobiles. The thesis introduces ColourFAST features which contain a compact feature vector of colour change values and an orientation for each feature point. The feature algorithms presented in this thesis process information in 'real time', with the objective on high data throughputs, whilst still maintaining suitable accuracy and correctness. It compares these new algorithms with well-known existing techniques as well as against their modified GPU-based equivalents. The research also develops a new GPU-based feature discovery algorithm for finding more feature points on an object, forming a cluster, which can be collectively used to track the object

and improve tracking accuracy. It looks at clustering algorithms for tracking multiple objects, and implements an elementary GPU-based object recognition algorithm using the generated ColourFAST feature data.

Bing Huang, Auckland University of Technology

Supervisors: Jiling Cao and Hyuck Chung

Date: October 2014

Title: **Real Option Games with Stochastic Volatility**

This thesis presents several real option models to address investment-timing decision problems in various scenarios. The traditional NPV method only considers the difference between the future cash flow and the cost of a project, but ignores the future risk of the project. The concept of an American call option is used to improve the NPV method, and it is re-named as a real option. Classical real option problems are considered in a framework where the instantaneous volatility of the project value is given by a constant. Ting et al. [43] carried out an asymptotic approach in a single firm model by letting the volatility parameter be a stochastic process. In particular, they assumed that the project value is given by the Heston model. In this thesis, the project value is determined by Heston model, and a similar asymptotic approach is applied to classical real option models with two firms as well as another real option model in which suspending the project is allowed. Several numerical examples and comparisons are provided to show how the additional uncertainty in the volatility affects the investment thresholds and the payoffs of firms in different scenarios.

In addition, real option models with two firms can also be considered in competitive situations. Such models are also regarded as strategic real option games. This thesis presents several types of strategic real option games. In a standard framework of strategic real option games, 2-player non-cooperative games under complete information are considered, and both pure strategy equilibria and mixed strategy equilibria are obtained. If both firms agree to cooperate with each other in a game, then the game is called a 2-player cooperative game and the bargaining solution can be obtained. Lastly, we study mixed strategy equilibria of a strategic real option game with asymmetric information which is similar to that in [16]. Our result shows that the firm with complete information will always take the advantage.

REPORTS ON EVENTS

2014 ICM and BRIDGES in Seoul

Figure 1: With Ben Green (Oxford) and Jens Marklof (Bristol) at the ICM 2014 opening ceremony.

The International Congress of Mathematicians in Seoul, known as Seoul ICM 2014, set a new record by attracting 4,500 mathematicians. This overwhelming number of participants was in no small part due to a Korean initiative called the NANUM programme that supported 1,000 mathematicians from developing countries to come to ICM. Nanum means 'generous sharing' in Korean and the initiative made Seoul ICM 2014 very special. Furthermore, enormous efforts were made to advertise the importance of the ICM, and the fact it was held in Seoul, to the general public; the exhibitions included a professionally designed set-up to promote mathematics to high-school students, there were two high-profile public lecturers, and Seoul ICM 2014 marked the establishment of the Leelavati Prize for popularisation of mathematics, which is to be a continuing prize awarded by the International Mathematical Union (IMU) at every future ICM.

The opening ceremony took place in a huge room, heaving with people, press, security and officials. This was something else! The excitement was tangible and everyone had a strong sense that history was about to be made. The enormity of it all did make me feel a bit lost and worried whether I would actually enjoy this meeing. However, the feeling quickly disappeared as I realised that it is possible to meet many colleagues and friends among 4,500 mathematicians. I found great seats almost in the front row, sitting next to Bernd Krauskopf and Jens Marklof, a friend and former colleague from Bristol, and with Ben Green, who visited Auckland last year, in the row behind us.

Figure 2: Marcelo Viana and Bernd Krauskopf.

It was a very nice surprise to meet Marcelo Viana (IMPA, Brazil) already before the start of the ceremony. Marcelo was a postdoc in Groningen when Bernd and I did our PhDs there. We had not seen each other in a long time and there was much to talk about. Marcelo is one of the two Vice Presidents of the 2011–2014 IMU Executive Committee and he told us that he was actually going to be the Chair of the next ICM, which will next be held in Rio de Janeiro in 2018.

The opening ceremony was an incredibly professional spectacle. Hyungju Park, the Chair of Seoul ICM 2014, formally opened the Congress. Ingrid Daubechies, the President of the IMU, followed with a second welcome. Then there was a formal ceremony welcoming Park Geun-hye, the President of the Republic of South Korea. She would have the honour of handing out the Fields Medals. This was indeed a very historic moment: here were two very powerful women on stage to congratulate Maryam Mirzakhani, the first ever female Fields Medallist. Of course, there were other extremely worthy prize winners, — the other Fields Medallists Artur Avila, Manjul Bhargava and Martin Hairer, and the Nevanlinna Prize winner Subhash Khot, — but Seoul ICM 2014 will be remembered as the ICM where, finally, a woman won the Fields Medal.

Figure 3: From left to right: Subhash Khot, Martin Hairer, Manjul Bhargava, President Park, Maryam Mirzakhani, Ingrid Daubechies and Artur Avila.

Even though I had never been at an ICM before, I could tell that there was something extraordinary about the unusually large number of high-school students at this meeting. These high-school students were not just coming from schools in Seoul, but from much further away in Korea! They were on school trips to experience the thrill of discovering new mathematics and to be part of this historical moment. By the time we reconvened after lunch for the Laudationes of the Fields Medallists and the Nevanlinna Prize winner, most high-school students were wearing official name badges, but instead of their names, each read: "Dreaming of a Fields Medal." The students were not just dreaming, they also wanted to get autographs and have their pictures taken with the famous prize winners. The first day was a particularly good day for them, because it ended with a public lecture by James Simons; here, the high-school students took the opportunity to ask questions and it was impressive how unnerved they were mustering up the courage to speak into a microphone, some even doing so in English, with thousands of mathematicians listening.

Figure 4: Five of the New Zealand participants: Vaughan Jones (Auckland), me, Bernd Krauskopf, Winston Sweatman (Massey and President of the NZMS) and Maarten McKubre-Jordens (Canterbury).

Figure 5: Ingrid Daubechies (IMU President) and Bill Barton (Auckland) at Bridges.

The next day, I went to a different opening: that of the Bridges Conference on Mathematics, Music, Art, Architecture and Culture, which was held at the Gwacheon National Science Museum in Seoul in parallel with ICM; this annual meeting normally alternates between the US and Europe, but IMU President Ingrid Daubechies asked that it be held in Seoul as another effort to communicate mathematics to the wider public. Bernd Krauskopf and I were both invited as keynote speakers at Bridges, which meant that we had to divide our time between two different venues. This had its disadvantages (I missed Martin Hairer's Fields Medallist talk!) but surprising uses of mathematics presented by Bridges speakers on topics as diverse as sculpture, dance, and juggling were a delightful alternative.

Apart from attending talks at either meeting, there were many opportunities to meet and speak with individuals. With so many people attending the same conference, it hardly mattered that the event was held in a metropolis like Seoul; almost every person you bumped into was a mathem-

atician. You met them for breakfast in the hotel, you briefly spoke with them in the lift, you found them in the metro and, best of all, you joined them for all kinds of receptions organised by Mathematical Societies of different countries. These were the moments to meet the Fields Medallists in person and there was actually time to talk to them too.

Figure 6: Left: the ICM conference dinner, from left to right: Bernd Krauskopf, Stefanie Hittmeyer (Auckland), Christiane Rousseau (U. de Montréal), Nalini Joshi (U. of Sydney), Cheryl Praeger (U. of Western Australia) and John Henstridge (Data Analysis Australia). Right: traditional Korean lunch with Cédric Villani (Lyon).

The ICM conference dinner took place after the first week. Hyungju Park welcomed everyone with a far more relaxed speech now that the ICM was already well on its way. He told us that the order of the medals had been mixed up when the Fields Medals were handed out by President Park: every single Fields Medallist was awarded someone else's medal! Now what are the odds of that? When I asked Martin Hairer about it later, it turned out that he was the one who had noticed it: the evening after the ceremony, he had taken his medal out of the packaging to admire it. And then he noticed it wasn't his, but it was Maryam Mirzakhani's! Only after he reported the mistake did the others find out that they hadn't gotten their correct medals either.

Figure 7: Dr. Shaffer and Mr. Stern Dance Ensemble presents mathematical poetry with an Asian touch.

Harri Varpanen (Aalto University, Finland) introduces new juggling moves through group theory.

My presentations were both only in the second week of the conference. Bernd and I gave a double-act at Bridges on the Monday, immediately following a lecture by Cédric Villani (Lyon, France, 2010 Fields Medallist). You can imagine that we were rather thrilled to follow such a high-profile speaker. The audience included many high-school students attending with their teachers. Unbelievably, we too got surrounded afterward by students wanting our autographs and their photos taken! At the end of the session, the keynote speakers were treated by Oh Nam Kwon (Seoul National University and main local organiser) to a traditional Korean lunch, where we got to try very special teas, three-year old kimchi and all sorts of other dishes. My ICM invited lecture in *Section 17: Mathematics in Science and Technology* was scheduled on the following day, as the first talk in the session with Daya Reddy (Cape Town, South Africa), Andrew Stuart (Warwick, UK) and Thaleia Zariphopoulou (Austin, US).

On each day, there were three plenary talks in the morning and one plenary after lunch, followed by a programme of ten parallel sessions. The Laudationes were each of superb quality. My favourite was the Laudatio by Étienne Ghys on Artur Avila's work in the area of Dynamical Systems. I was also very impressed by the presentations of Manjul Bhargava, Ben Green and Mikhail Lyubich. All plenary and invited talks have been recorded and posted on YouTube, so you can enjoy them even if you missed them in Seoul. It

Figure 8: Some pieces from the art exhibit at Bridges; from left to right: *Fractal Installation #2* by Mehrdad Garousi, *Rotating Fans Tessellation* by Halina Rościszewska-Narlock, and *Unfolding Julia* by Jean Constant who won Best-in-Show.

was very unfortunate that Maryam Mirzakhani had to leave early and could not give her talk. At times it was difficult to choose which talk to go to, because, for example, *Section 9: Dynamical Systems and Ordinary Differential Equations* typically had two and, on one day, even three sessions running in parallel. My personal highlight of this ICM was the Abel lecture by John Milnor. His performance was truly stellar, leading the audience from the very basics in topology through its history covering four centuries. He discussed a series of well-chosen examples, increasing the dimension each time, in such a way that everyone felt they had understood it until the very end. His surprise after one hour: "Oh, I seem to be using much more time... Mr. chairman, how should I proceed?" was endearing and everyone agreed with the chairman's response: "Please, just go on, we are enjoying it."

The finale, for me, of what had been a most enjoyable ICM, was the 'Donauction' on the next-to-last day of ICM. This new initiative is a kind of raffle, where artists donated pieces of art, many from the Bridges art exhibit, to help raise funds for the 'Adopt a Mathematics Graduate Student' programme. Started by the Friends of IMU, this programme supports graduate assistantships that help talented mathematics graduate students at a university in the developing world to continue their studies. Cédric Villani was auctioneering off the pieces, one of which was *Arachnid*, the spider brooch that he had been wearing at the 2010 Fields Medal Ceremony. The Best-in-Show of the Bridges art exhibit, the piece *Unfolding Julia* by Jean Constant (Santa Fe, US), was also part of the Donauction and went to Ki Won Kim (Silla University, Korea). Villani's spider was taken home by Günter Ziegler (FU Berlin, Germany).

Hinke Osinga

Grant recipient report

With support from the New Zealand Mathematical Society travel grant, Jennifer Creaser (supervised by Bernd Krauskopf) and Peter Langfield (supervised by Hinke Osinga) of the University of Auckland participated in the 10th biennial AIMS Conference in July 2014 in Madrid, Spain. Whilst in Europe, they took the opportunity to visit several universities in England to present their work and meet internationally acclaimed experts in their field.

This year, the AIMS conference attracted over 2500 attendees from around the world. The topics of the conference ranged from analysis of differential equations and dynamical systems to applications to a wide variety of real-world phenomena, spread across nearly 130 parallel sessions. There were twelve keynote speakers, all of whom were leading researchers in the fields of dynamical systems, differential equations and numerical analysis. There were several highly relevant talks, for example by Carlos Simó and Bernold Fiedler. Of particular interest was the special session on "Rigorous and numerical methods for invariant manifolds", which brought together the latest research on aspects of computation of invariant objects in finite- and infinite-dimensional systems, a subject at the heart of both Jennifer's and Peter's work. Jennifer presented her talk "The Lorenz system near the loss of the foliation condition" and had fruitful discussions with Jason James and Maciej Capinski regarding numerical computation and computer assisted proofs in the Lorenz system. Peter presented his talk "Interaction of forward- and backward-time isochrons" and had the pleasure of meeting with Gemma Huguet and Antoni Guillamon to discuss the development of algorithms for the computation of two-dimensional isochrons.

Jennifer and Peter then headed to England for academic visits. Jennifer gave seminars at the University of Leeds and Imperial College London. In particular, at Imperial College London, Jennifer had informative discussions with Dimitry Turaev and Sebastian van Strien about the intricacies of the attractor in the Lorenz System. The insight from these discussions helped shape the direction of Jennifer's PhD thesis and brought her current work on T-points into perspective. Peter visited Steve Coombes at the University of Nottingham and Sebastian Wieczorek at the University of Exeter. At each university he gave a seminar on his most recent work on the interaction of isochrons. Especially, at the University of Nottingham, he learnt a lot about actual applications of isochrons in biological systems, for example, how perturbations can also induce chaotic dynamics.

Jennifer and Peter would also like to thank the University of Auckland for contributing towards the attendance costs of the conference.

Jennifer Creaser and *Peter Langfield*

Grant recipient report

I am a masters student from Victoria University, and in November with the generous help of NZMS was able to attend the NZMASP conference in Whitianga. The NZMASP conference is a graduate conference with a relaxed and supportive atmosphere in which all graduate students present a 15 minute talk about their work. There was a wide range of topics that included subjects in pure maths, applied maths, statistics and history of mathematics. This conference was a great experience for me as it was the first time I have presented my talk on "Modelling Surtseyan ejecta". By listening to other speakers I have learned a lot about how to effectively present a talk and this along with helpful comments about my talk will improve my presentation skills in the future. At the conference I learned a lot about different areas of mathematics from the various speakers and I also had an enjoyable time meeting many of the other students doing post graduate degrees around the country. I would once again like to thank NZMS for their generous help in providing me with this valuable experience.

Emma Greenbank

Celebration of Diversity in Mathematics

On 10 September 2014 a half-day symposium entitled "Excellence in Mathematical Sciences: A Celebration of Diversity" was held at the University of Auckland. Organized by Golbon Zakeri (UoA, Engineering Science), the meeting contained invited talks by Hinke Osinga, Gill Dobbie, Rosemary Bailey, Marston Conder, Tava Olsen, Cather Simpson. Marston's talk was an introduction to the work of Maryam Mirzakhani, the first female Fields' Medallist, whose award inspired the event. About 50 people attended.

Full details of the awards for 2014, which were announced at ICM in Seoul in August, can be found at: www.mathunion.org/general/prizes/2014/. In addition to the first woman, this year saw the first Latin American recipient (Artur Avila).

Mark C. Wilson

New Zealand Mathematics and Statistics Postgraduate conference 2014

The 8th annual New Zealand Mathematics and Statistics Postgraduate (NZMASP) conference was held at the Aotearoa Conference Centre in Whitianga on the beautiful Coromandel peninsula from 17–20 November 2014.

NZMASP is a student-run and organised conference this year attended by 56 students from Honours, Masters and PhD programs from universities across New Zealand. This is a unique opportunity for PhD students to network with their fellow postgraduates from across the country and cultivate the connections between New Zealand universities.

Talks given at NZMASP14 were well prepared, interesting and of an excellent standard. Attendees gained valuable experience ahead of bigger events such as the NZ Mathematical Society Colloquium and the joint conference of the NZ Statistical Association and Operations Research Society. The large variety of topics ranged from the dynamics of toothpaste to mathematics under Soviet socialism. Around half the talks were in applied

mathematics, a third were in pure mathematics and the remainder in statistics with one history of mathematics talk. Congratulations go to the winners of the people's choice prizes for best talks, awarded to Abhishek Bhardwaj (University of Auckland), Rachelle Binny (University of Canterbury), Jack Simpson (University of Canterbury) and Timm Treskatis (University of Canterbury).

NZMASP14 conference participants

In addition to the student presentations there were three excellent plenary talks given by speakers from the University of Auckland: Dr Rachel Fewster (statistics) on how to fake data if you must, Dr Igor Klep (pure mathematics) with entertaining linear matrix inequalities and Dr Caroline Yoon (mathematical education) contemplating what it is to be a mathematical educator.

The organisers this year were Sebastian Boie, Jennifer Creaser, Jung Min (Sylvia) Han, Ragheb (Cris) Hasan and Peter Langfield from the University of Auckland. Due to generous sponsorship NZMASP14 was free for students from New Zealand universities to attend. The conference organisers would like to thank the Universities of Auckland, Waikato, Victoria and Massey, and also the Allan Wilson Centre, ANZIAM, the Biomathematics Research Centre, Harmonic Analytics, NZMS, the NZSA Campbell Bequest Fund and the Operations Research Society for their contributions. Special thanks go to the following people for their support and assistance in making this year's conference possible: Vivien Kirk, Marston Conder, Claire Postlethwaite, Mike Plank, Charles Semple, Stephen Joe, Geoff Whittle, Gaven Martin, Alex James and Winston Sweatman.

The baton has been handed to PhD students from the University of Waikato who will organise next year's NZMASP conference.

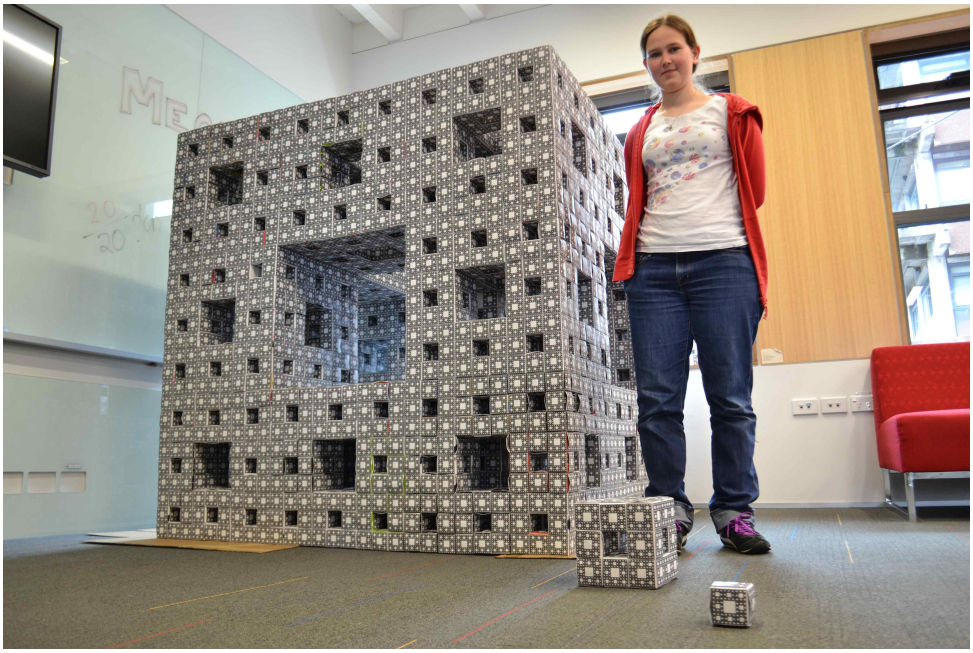
Mega Menger

The study of fractals was founded by Felix Hausdorff, Waclaw Sierpiński, Karl Menger and others. In 1918, Hausdorff gave a definition of geometrical dimension which included non–integer dimensions. In 1926 Menger published his concept of the Menger Sponge, a 3–dimensional fractal, which can be made by taking a cube and cutting out a square section through the centre in each of the 3 orthogonal directions. Then each of the resulting 20 smaller cubes is cut out in the same way to give 400 smaller cubes, and so on until you've removed infinitely many pieces. So each Menger Sponge is made from 20 identical-but-smaller Menger Sponges. This results in a selfsimilar fractal polyhedron which has zero volume and infinite surface area! Its Hausdorff dimension is $\log(20)/\log(3) = 2.726\ldots$ In 1950 Karl Menger undertook a lengthy voyage to New Zealand (probably by ship),

to visit his friend Professor Henry George Forder. I was then a Stage 2 student: I remember meeting Menger, and I think that I attended a talk by him. In 1971 John Butcher edited the Festschrift volume for Professor Forder: "A Spectrum of Mathematics: Essays Presented to H. G. Forder", published by Auckland University Press & Oxford University Press. That contained Menger's lengthy essay *The new foundation for hyperbolic geometry*, which was reprinted in the collected edition of his major mathematical papers "Selecta Mathematica", Springer Verlag, 2002, Volume 1.

Matt Parker (University of Salford, Manchester) and Laura Tashman (James Madison University, Virginia) organized the Mega Menger event on October 25–26 which was held at 20 sites around the world, starting at the Auckland Art Gallery. At each site, a stock of about 50,000 business cards would be assembled into a Menger sponge about 1.5m high, and weighing about 90kg. Eight thousand cubes (Level 0 of the sponge) would be constructed from 3 cards each (folded and stuck); then 400 cubes (Level 1) would be assembled, each from 20 Level 0 cubes; then 20 cubes (Level 2) would be assembled, each from 20 Level 1 cubes; then the Level 3 cube would be assembled from those 20 Level 2 cubes. Those 20 Level 3 cubes around the world, if they were brought together, could form a Level 4 Menger sponge about 4.5m high!

The Auckland event was arranged by Dr Nicolette Rattenbury, who is the Administrator for the Science Scholars Programme in our Faculty of Science. She assembled a team of students of mathematics and physics, who worked in the Atrium of Auckland Art Gallery over Labour Weekend to assemble a Menger Sponge. Literally hundreds of people stopped and helped create our sponge, while learning about fractals at the same time. As happened at many of the 20 locations, they unfortunately didn't quite manage to finish our sponge in the allotted time, but they did get a face finished. When they went to pick up the sponge to transport it back to the University they discovered that the sponge had been placed by the recycling bin it and was in many, many pieces. The pieces were moved back to the Department of Mathematics at The University of Auckland and our team repaired the damage. We finished Level 3 on 11 December.



Our Menger Sponge (with Yael Ben-Tal; photo: Jacob Martin)

Garry J. Tee

38ACCMCC

The Australasian Conference on Combinatorial Mathematics and Combinatorial Computing took place at Victoria University in the first week of December. The conference has been running since 1972, and the Wellington meeting was the 38th in the series. This is only the 8th time that the conference has taken place in New Zealand, and the first time it has been hosted in Wellington. Exactly one hundred participants attended, from New Zealand, Australia,

Spain, Thailand, Taiwan, the United States, France, Japan, Austria, the Czech Republic, Canada, India, Slovenia, the United Kingdom, and Iceland. There were 72 contributed talks, as well as 9 plenary talks, covering many aspects of combinatorics: Latin squares, enumeration, graphs, geometries, matroids, permutation patterns, codes, and designs. A special highlight was a talk by Molly Melhuish. Molly has lived in Wellington for many years, but is the daughter of the American mathematician, Hassler Whitney. Whitney was a founding figure in cohomology theory, singularity theory, differential topology, and matroid theory, and is certainly one of the most influential mathematicians of the last century. Molly spoke about her life and her family, almost all of whom, apart from being scientists, are keen musicians, sailors, and climbers. Visitors from overseas especially enjoyed the excursion to the Zealandia eco-sanctuary to see some native New Zealand flora and fauna, as well as being entertained at the conference dinner by the Kapa Haka group of Newlands Intermediate School.

Slides from conference talks, as well as some photos, can be found on the conference website: http://msor.victoria.ac.nz/Events/ACCMCC/WebHome.

Dillon Mayhew

Heidelberg Laureate Forum 2014

The second Heidelberg Laureate Forum was held from 21–26 September 2014 with the generous support of the Klaus Tschira Stiftung (Klaus Tschira Foundation) in the romantic city of Heidelberg, Germany. The event is modelled on the Lindau Nobel Laureate Meetings and brought together young researchers at various stages of their mathematical and computer science careers and prize winners of the Fields Medal, Abel Prize, Turing Award and Nevanlinna Prize. This year's event was attended by 24 Laureates, including two of this year's Fields medallists (Manjul Bhargava and Martin Hairer) and last year's ACM Turing Award winner Leslie Lamport, 200 young researchers from over 59 countries, and other distinguished guests from both the mathematical and computer science communities.

Professor Mori (Fields Medallist and president-elect of IMU) compares algebraic geometry to impressionist paintings;

Oktoberfest get-together

Besides the lectures, panel discussions and workshops, there were other social events that made the week memorable. There was an Oktoberfest get-together at the local Brauhaus and a boat cruise along the Neckar River one afternoon, providing great opportunities to mingle with the Laureates.

On Wednesday morning there was a visit to one of the local institutions in Heidelberg. I went to the Max Planck Institute for Astronomy and was treated to a wonderful demonstration involving liquid nitrogen at the Infrared Space Astronomy Lab and a very cool exploration of the universe in the planetarium. The whole event concluded with an unforgettable tour and farewell dinner at Heidelberg Castle.

The atmosphere was lively and social, and a lot of interactions between the young researchers and the Laureates were made. It was exciting to meet such an international group of fellow researchers including undergraduates, PhD students and postdocs, pursuing a wide range of research interests from arithmetic geometry to software systems. The general consensus was that everybody had an incredible time at the event!

For more details about this year's event and applications for next year's event see the HLF website: http://www.heidelberg-laureate-forum.org

Hopefully Kiwis will make a bigger presence at the event in subsequent years!

Matthew Randall

Sunset over Heidelberg

NZMS NOTICES

Reminder about financial assistance

The NZMS invites applications for Student Travel Grants from students to support them presenting their research at conferences, attending workshops, and developing new collaborations.

http://nzmathsoc.org.nz/downloads/applications/NZMS_StudentTravelGrantApplication_2014.pdf

Members of the NZMS may apply for financial assistance with the costs of hosting mathematical visitors, organising conferences or workshops, attending conferences, and any other mathematical research-related activity.

http://nzmathsoc.org.nz/downloads/applications/NZMS_FundingApplication_2014.pdf

Awards made at the 2014 Colloquium

The 2014 NZMS Research Award went to Dimitri Leemans (University of Auckland) "for his striking contributions to algebraic combinatorics that combine techniques from algebra, graph theory, combinatorics and number theory for the exploration and classification of highly symmetric geometric structures" (this was received on his behalf by Tom ter Elst, 2012 NZMS Research Award winner.)

The 2014 NZMS Early Career Award went to David Simpson (Massey University) "for his contributions to the analysis of the effects of randomness and uncertainties in nonsmooth dynamical systems" (this was received on his behalf by Chris Tuffley.)

The 2014 Aitken Prize for the best contributed talk by a student went to Timm Treskatis (University of Canterbury) for his talk "Accelerated gradient vs. primal-dual methods in nonsmooth optimisation". Honourable mentions went to Karen McCulloch (Massey University) for her talk "Analytical expressions for infection path probabilities of an SIR model on small networks" and Ilija Tolich (University of Otago) for his talk "Structure theorems for star-commuting power partial isometries".

The 2014 ANZIAM poster prize for the best poster by an early career researcher went to Andrea Babylon (Massey University) for her poster "Modelling Leptospirosis in Livestock".

The following were awarded Fellowships of the New Zealand Mathematical Society (announced at the dinner): Astrid an Huef, Gaven Martin, Graham Weir and Sir Vaughan Jones. Astrid was presented with her certificate at the dinner.

Photos by Mark McGuinness from the joint Australian-New Zealand Mathematical Society meeting can be found at https://www.dropbox.com/sh/qhzw6aqxtqmnz69/AADrk3jUYoc0lIUhxjw08Fnja?dl=0.

GENERAL NOTICES

Heidelberg Laureate Forum

(From Martin Groetschel, Secretary of the International Mathematical Union)

Dear colleagues,

The first two Heidelberg Laureate Forums (HLF) which took September 2013 and 2014, turned out to be very successful events. They brought together outstanding students in mathematics and computer science with winners of the most prestigious awards in these two disciplines:

Abel, Fields, Nevanlinna, and Turing Laureates.

The Heidelberg Laureate Forum was started by the Klaus Tschira Stiftung and is being organized by the Heidelberg Laureate Forum Foundation in cooperation with

– The Norwegian Academy of Science and Letters
– The Association for Computing Machinery
– The International Mathematical Union

which are the awarders of the prizes mentioned.

Detailed information about the Heidelberg Laureate Forum can be found at http://www.heidelberg-laureate-forum.org/.

Preparations for the 3rd HLF are well underway. Effective November 17, the online application tool is up and running. The press information released on November 17, 2014, announcing the start of the application period for the 3rd Heidelberg Laureate Forum (HLF), can be found below. The HLF application poster and fact sheet are attached and available for download at: http://www.heidelberg-laureate-forum.org/download-area/.

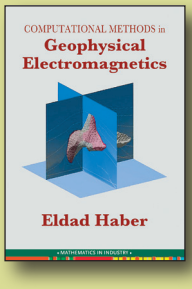
We would greatly appreciate if you could help spread the word. Please feel free to forward the press release and the attached information to all interested parties.

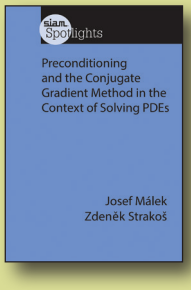
Kalman Prize award

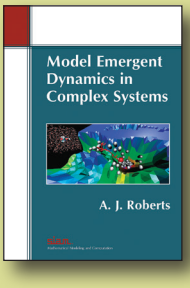
From David Gauld:

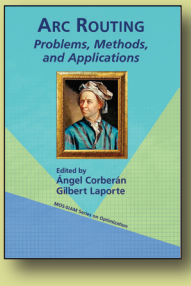
As you may recall the trustees of the Margaret and John Kalman Trust decided to establish a prize, to be known as the Kalman Prize, for the best paper published in the NZJM over the past few years. A committee was set up by the Editor, Gaven and after a lot of care it was recommended to the trustees that the prize be offered to Dr Cédric Bonnafé for his paper "Semicontinuity properties of Kazhdan-Lusztig cells," New Zealand J. Math. 39 (2009), 171192. The trustees accepted the recommendation and Dr Bonnafé has accepted the prize. I have added a bit to the NZJM website at http://nzjm.math.auckland.ac.nz/index.php/New_Zealand_Journal_of_Mathematics (scroll down to the last paragraph of the section on the Kalman Prize).

New & Notable Titles from SIAM









Computational Methods in Geophysical Electromagnetics

Eldad Haber

Mathematics in Industry 01

This monograph provides a framework for students and practitioners who are working on the solution of electromagnetic imaging in geophysics. Bridging the gap between theory and practical applied material, it provides a simple explanation of finite volume discretization, basic concepts in solving inverse problems through optimization, a summary of applied electromagnetics methods, and MATLAB® code for efficient computation.

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SIAM Spotlights 1

This is the first title in SIAM's new Spotlights series of brief and enlightening books on timely topics. It discusses the interplay between modeling, analysis, discretization, matrix computation, and model reduction. The authors link PDE analysis, functional analysis, and calculus of variations with matrix iterative computation using Krylov subspace methods and address the challenges that arise during formulation of the mathematical model through to efficient numerical solution of the algebraic problem. This text challenges commonly held views, addresses widespread misunderstandings, and formulates thought-provoking open questions for further research.

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Ángel Corberán and Gilbert Laporte, Editors

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Finite Element Methods for Computational Fluid Dynamics: *A Practical Guide*

Dmitri Kuzmin and Jari Hämäläinen

Computational Science and Engineering 14

This informal introduction to computational fluid dynamics and practical guide to numerical simulation of transport phenomena covers the derivation of the governing equations, construction of finite element approximations, and qualitative properties of numerical solutions, among other topics. The authors begin at a basic level and advance to numerical tools for increasingly difficult flow problems.

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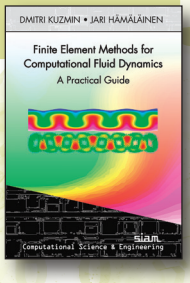

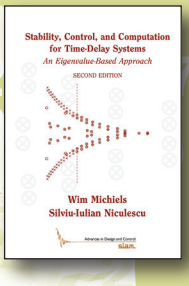

Stability, Control, and Computation for Time-Delay Systems: *An Eigenvalue-Based Approach, Second Edition*

Wim Michiels and Silviu-Iulian Niculescu

Advances in Design and Control 27

In this revised edition, the authors make the leap from stabilization to the design of robust and optimal controllers and from retarded-type to neutral-type delay systems, thus enlarging the scope of the book within control. They include new, state-of-the-art material on numerical methods and algorithms to broaden the book's focus and they increase the number and range of applications to better illustrate the effectiveness and generality of their approach.

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