

**New Zealand Institute of
Mathematics & its Applications**

ANNUAL REPORT

for the year 2008

**Yet to be approved by the
NZIMA Governing Board**

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OVERVIEW FROM INTERIM CHAIR OF THE NZIMA BOARD

Len Cook, CBE, Chair of the NZIMA's Governing Board, reports:

I am delighted to have taken up the mantle as interim Chair in time to present the annual report of the New Zealand Institute of Mathematics and its Applications (the NZIMA), on behalf of its Governing Board.

For the mathematical and statistical sciences in New Zealand, as in many fields of scientific endeavour, the fragmentation of institutions and funding have meant that we have been hugely reliant on individuals to bring cohesiveness and long term direction to both what we achieve nationally, and to our capacity to sustain these achievements. The Centres for Research Excellence have been one pragmatic response to this. Although the consequent TEC funding establishing the NZIMA has proven to be short term, the opportunity exists to sustain NZIMA in its unique and invaluable contribution to collective leadership of mathematical sciences in New Zealand.

Leadership in quantitative sciences is absolutely essential in the information age. This embraces not only the capacity to understand the researchable and answerable questions relevant to New Zealand, and societies and economies like it, but the capacity to have an intimate association with centres of excellence wherever they are around the globe.



Len Cook

In almost all sciences, professions and other fields of endeavour, the continually burgeoning capacity to measure, monitor and analyse information has radically changed the nature of decision-making. Usually the mathematical and statistical sciences have played an integral part in bringing about threshold shifts in the science of decision-making. Indeed, without such competence, we have many examples where the capacity to analyse information has lagged the increased capacity to measure and monitor. That same innovation offers opportunity to introduce new ways of analysing and managing longstanding processes and systems, not only industrial, but those in commercial, health and social service settings.

The report of the Directors and Executive committee presents a rich survey of current excellence in many fields in the mathematical sciences. It is also a reminder of the breadth and scale of research in the mathematical sciences that underpin the scientific, industrial and commercial activity central to wealth creation in New Zealand. Our future capacity as a nation to compete in commodity, service and knowledge markets will be influenced by our capability in collaborating internationally in advancing knowledge fundamental to the information based research that so dominates innovation around the world. Although we are now well placed for this in the mathematical sciences in New Zealand, we risk doing insufficient to both sustain what we have, and diminishing our capacity at a time when we should be rising up to meet the opportunities the information economy and society generates.

It is heartening to see that 2008 has seen the NZIMA continue to mature, building yet further on its already impressive international reputation in the mathematical sciences, while achieving beneficial outcomes for New Zealand and communicating what it does to the wider scientific and educational community. In terms of value for money, the NZIMA really delivers.

Despite an outstanding reputation internationally and support from university mathematics computer science and statistics departments as well as professional societies in New Zealand, the NZIMA has had to grapple this year with the reality of its loss of funding in last year's CoRE round. The future of this phenomenal Institute now hangs in the balance. Its loss would be a loss for the whole of New Zealand.

In 2002 the NZIMA set itself the goals of creating and sustaining a critical mass of researchers in concentrations of excellence in mathematics and statistics and their applications, and "lifting the game" for the mathematical sciences in this country, using as models a number of other renowned mathematical sciences institutes overseas. This they have done in many, many ways.

Among the things that continue to impress me about the NZIMA is the way it epitomises excellence.

For example, the list of honours and awards being won by the NZIMA's researchers and students is impressive, and keeps growing. Publications in top international journals, special issues devoted to the NZIMA's programmes, and large and increasing citation rates (far in excess of the worldwide average for the mathematical sciences) all attest to world class standing.

This excellence has not, however, been confined to particular areas of the discipline — wonderful outcomes are being seen in both fundamental and applied aspects of the mathematical sciences, very positive interactions with a wide range of other disciplines (including biology, computer science, ecology and medicine, as well as the more traditional engineering and physics), and concrete applications to business, industry and society in general.

What is clear is that the main players of the NZIMA have used their CoRE status and funding to support the development of the mathematical sciences in New Zealand far beyond the confines of their own research groups — foremost among these being the NZ-IMAgEs bulletin and the MathsReach website for schools. This website, which has won acclaim from teachers around New Zealand has undergone a major reworking, and will be relaunched early next year with even more videos and articles.

These things have come about because of the talents and leadership of the NZIMA's principal investigators and management team, and because of their desire to achieve good things for science (in the broadest sense) and for New Zealand.

I applaud the NZIMA and all those involved in it, particularly the two Co-Directors, the Research Manager and the Executive Committee for their vision and efforts. There is no doubt in my mind that the NZIMA is pursuing the goals of the Centres of Research Excellence Fund in outstanding fashion.

REPORT FROM DIRECTORS AND EXECUTIVE COMMITTEE

We are very pleased to report on another excellent year of NZIMA activities.

2008 began for us with a summer meeting at Nelson as part of the programme on conformal geometry and geometric approaches to partial differential equations. Its principal themes were the use of conformal geometry and related techniques to study geometric and topological properties of manifolds and the use of geometric approaches to study partial differential equations.

The meeting attracted over 40 participants including a dozen students from New Zealand and overseas. Most of the talks were pitched at an ideal level for an introduction to the area. It featured outstanding researchers, each giving a series of lectures surveying recent developments in the area.

A number of lectures were given by Professor Peter Cameron (Queen Mary, University of London) at university centres around New Zealand in April. Peter Cameron was visiting as the London Mathematical Society's Forder Lecturer for 2008 (made possible from a bequest to the LMS by Henry George Forder, who was Professor of Mathematics at the University of Auckland from 1934 to 1955). One of his lectures was entertainingly titled "Sudoku: Is it Mathematics?". He was also interviewed by Kim Hill on National Radio.

During the year we initiated two new thematic research programmes. One is on, "Energy, Wind and Water", led by Professor Mike O'Sullivan (University of Auckland), and the other is in Mathematics Education, focussing on the mathematical and statistical knowledge for teachers at senior levels.

In addition, we are continuing to support several postgraduate research projects being undertaken by Masters and PhD students around New Zealand, on a range of topics from pure and applied mathematics and statistics — see the section on Research by Postgraduate Students.

We hosted visits by two short-term visiting Maclaurin Fellows: Professors Edgar Knobloch (University of California, Berkeley), and Michael Eastwood (University of Adelaide). Professor Eamonn O'Brien (University of Auckland) took up his full-year Maclaurin Fellowship for 2008/09. Eamonn O'Brien is a world leader in the specialist field of computational group theory, and his research has been concentrating on algorithms for computational recognition and analysis of linear groups (defined as matrix groups over finite fields) and the structure and classification of groups of prime-power order.

Also in 2008 we continued our pursuit of initiatives aimed at improving inclusion and retention of people from under-represented groups. A second workshop for women researchers in the mathematical sciences took place in November, following on the success of the workshop last year.

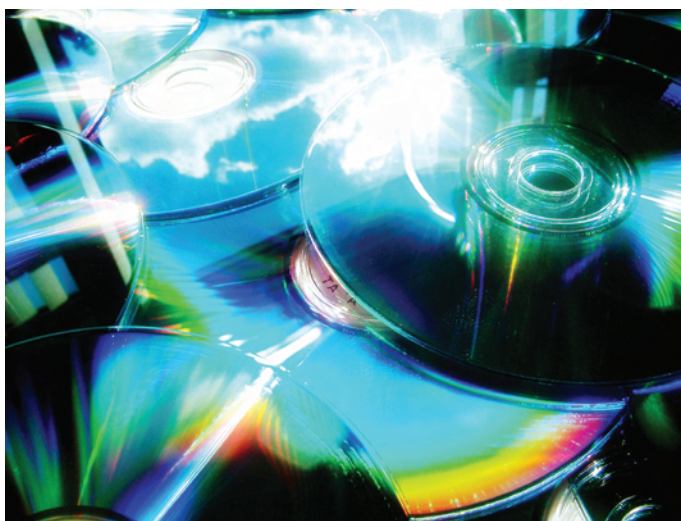
As previously, we sponsored several local conferences and short-term visitors, both through our thematic programmes and otherwise, as we find these bring great benefits. Relatively small amounts of money (spent mainly on travel costs) have led to new

interactions and an increased level of excitement, especially among early and mid-career researchers.

The awards and honours being won by our researchers and associates continue to grow in number. See the section on Research Excellence for details.

Before closing, we would like to thank all those who have been involved positively in NZIMA's sixth year of operation, including (but not limited to) the following:

- The Chair and members of the NZIMA's Governing Board for their guidance and oversight
- Members of the Scientific Advisory Board for their advice and insight
- Members of the Executive Committee and others who have been involved in helping coordinate the NZIMA's activities
- Programme Directors and Maclaurin Fellows for their research and research leadership
- Margaret Woolgrove for her continued efficiency and initiative
- The Science Faculty Office at the University of Auckland for their ongoing support
- Heads of departments and leaders of professional societies in the mathematical sciences in New Zealand for their continued support.



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While it has been another full and satisfying year for the NZIMA, there is still no prospect of continued funding for our Institute beyond the middle of 2010. So much has been achieved within the mathematical community (and by extension, for the rest of the country, both intellectually and in other ways) that it is hard to imagine that this organisation may soon have to be laid to rest. We continue to hope that further funding will come available so we can build on our many successes.

Marston Conder FNZMS FRSNZ FTICA
Vaughan Jones DCNZM FRS FRSNZ

PROGRESS WITH RESPECT TO CoRE FUND OBJECTIVES

The Centres of Research Excellence (CoRE) Fund is intended to support research that:

- is of excellent (world-class) quality,
- leads to knowledge transfer, and
- is focussed upon New Zealand's future development.

Below are some of the highlights of the NZIMA's activities and achievements in 2008 that show we are meeting these objectives. Further details can be found elsewhere in this report.

Research Excellence

- Our programmes are bringing together some of the world's best researchers in the relevant theme area, providing an excellent basis for stimulating top quality research and training students in New Zealand.
- Significant advances in knowledge and applications are resulting from NZIMA activities - see the sections on Thematic Research Programmes, Maclaurin Fellowships and Postgraduate Research Projects.
- Researchers involved with the NZIMA published a large number of articles in some of the world's top mathematics journals in 2008, including *Advances in Applied Mathematics*, *Advances in Applied Probability*, *Advances in Mathematics*, *Annals of Pure and Applied Logic*, *Discrete and Computational Geometry*, *European Journal of Applied Mathematics*, *Journal of the American Mathematical Society*, *Journal of Algebra*, *Journal of Combinatorial Theory*, *Journal of the London Mathematical Society*, *Journal of Number Theory*, *Journal of Optimization Theory and Applications*, *Proceedings of the American Mathematical Society*, *Journal of Mathematical Biology*, and *Operations Research Letters*.
- NZIMA researchers have continued to win numerous honours and awards in 2008, including the following:



Ilze Ziedins, whose research was featured in Issue Five of NZ-IMAgés

- Bill Barton elected President of International Commission on Mathematical Instruction (ICMI)
- John Butcher elected Honorary Fellow of the European Society of Computational Methods in Sciences and Engineering
- Rod Downey elected Fellow of the Association for Computing Machinery (ACM)
- Mike Hendy awarded NZ Science & Technology Medal and NZ Mathematical Society's annual Research Award
- Ross Ihaka awarded the Pickering Medal of the RSNZ
- Gaven Martin awarded the Hector Medal of the RSNZ
- David Ryan elected Fellow of The Institute for Operations Research and the Management Sciences (INFORMS).

For more details, see the "Awards and Honours" section of this report.

Knowledge Transfer

- Each of the NZIMA's programmes have encouraged large numbers of students and professional mathematical scientists to take part in their conferences/workshops.
- Postgraduate students have been engaged in specific research projects by each of NZIMA's programmes, with a total of 63 students having been engaged both directly and on programme based research.
- The NZIMA organised or co-sponsored six other conferences and instructional workshops in 2008.
- In addition, many of the NZIMA's programmes have included a series of instructional lectures and/or seminars, for researchers from universities and CRIs, students, and interested parties from related disciplines, business/industry and relevant government departments.
- Our programme on Mathematics in the Nanosciences is highly multidisciplinary, involving interactions between researchers in mathematics, physics, chemistry and engineering.
- Our programme on Partial Differential Equations involves the application of mathematics to geothermal modelling, nanotechnology, sea-ice interaction, structural vibration and acoustics.
- Our programme on Modelling Invasive Species is stimulating interactions with the BioProtection CoRE, Landcare Research, AgResearch and the Canterbury Regional Council.
- Our programme on Algorithms involves intensive interaction between mathematics and computer science and applications in biology, ICT and social sciences.
- We have facilitated public lectures by high profile mathematicians such as Peter Cameron.

- Our twice-yearly newsletter, NZ-IMAgEs, produced two new issues, with the aim of showcasing a selection of mathematical activities across New Zealand, and making these accessible to a wider community.
- Our web-based resource, MathsReach (www.mathsreach.org), shows school students and teachers what lies beyond the school curriculum in mathematics and statistics, in terms of professional careers, research activity, hot topics, and interesting and important applications. Several new videos and articles were prepared for the site during the year.
- The NZIMA website (www.nzima.org) is continually updated with programme information as well as other opportunities and linkages.
- Research findings are announced at national and international conferences, and published in national and international refereed journals.
- A quarterly electronic newsletter of NZIMA activities, appointments and occasional “profiles” of key people (e.g. Maclaurin Fellows, scholars, programme directors) is issued to a wide range of stakeholders.

Contribution to National Goals

- The NZIMA has “lifted the game” for the mathematical sciences in New Zealand, by focusing resources for greatest effect, helping our researchers work at the leading edge of their disciplines, creating new knowledge and also being able to assimilate new knowledge very rapidly, thus strengthening research-led teaching
- We have developed an outreach programme to lift the profile of the mathematical sciences in the eyes of the public, schools, teachers and students, to increase awareness of possibilities and encourage greater enjoyment and participation in science and other subjects having a quantitative focus
- Our MathsReach resource is putting across the idea that there is “Maths behind every door”, highlighting the fact that mathematics underlies many recent advances in science, technology and everyday life and that mathematicians are involved in all of these areas
- Our membership of the IMSI and PRIMA consortia are providing excellent opportunities for New Zealand students to participate in summer schools and other activities organised by our partner institutes overseas
- We have encouraged the involvement of under-represented groups in research and postgraduate study in the mathematical sciences, and are celebrating their success.



Mike Langston, who visited New Zealand as part of the Algorithms Programme, being interviewed in Napier for the MathsReach website

- We are undertaking research that has potential and actual benefits for New Zealand's economy, society, and environment, such as the following:
 - Our programme on Modelling Invasive Species and Weed Impact is helping investigate the spread and subsequent impact of invading organisms in New Zealand ecosystems, in order to determine the optimal use of resources between the competing demands of controlling existing species and limiting new species, while maintaining biodiversity.
 - Our programme on Partial Differential Equations has been adapting methods developed in the cell-phone industry and in condensed matter physics to improve sound isolation in timber construction.
 - Research in our programme on Energy, Wind and Water is aimed at improving the approach to effective resource modelling and usage in New Zealand.
 - Our new programme in Mathematics Education will help to ensure the provision of a flow of competent graduates to help meet the needs of New Zealand's society and economy.
- With regard to national identity, the NZIMA's programmes and international linkages, and the high profile of our principals and their work, have fostered a growing international awareness of the quality and diversity of mathematical sciences research in New Zealand.

THEMATIC PROGRAMMES

The following eight programmes have now all been completed:

- Modelling cellular function
- Logic and Computation
- Numerical methods for evolutionary problems
- Phylogenetic genomics
- Combinatorics and its Applications
- Dynamical Systems and Numerical Analysis
- Geometry: Interactions with Algebra and Analysis
- Mathematical Models for Optimizing Transportation Services

It is noteworthy that the directors of two of our early programmes, "Modelling cellular function" and "Phylogenetic genomics", have since been invited to run programmes on similar topics at the Isaac Newton Institute for Mathematical Sciences in the UK. Prof. Mike Steel was co-director of a Newton Institute programme on Phylogenetics from September to December 2007, and Dr Nic Smith will co-direct a Newton Institute programme on "The Cardiac Physiome Project: mathematical and computational foundations" from June to August in 2009.

A summary of current programmes follows.

Hidden Markov Models

Hidden Markov models form a remarkably general and elastic mathematical framework for modelling partially observed complex systems (in which observed data do not directly reflect the underlying dynamics). Recent developments allow model testing and parameter estimation to be carried out within certain classes. This programme was set up with the aim of further extending and exploiting these developments through applications to a range of problems of local and international significance.

Programme director: Emeritus Professor David Vere-Jones (Victoria University of Wellington, and Statistical Research Associates)

This programme commenced mid-2005, and was completed in 2008.

One of the main aims of this programme has been to bring together New Zealand-based researchers who use hidden Markov models in a range of contexts, to share their own expertise and to learn from overseas experts about recent developments. Being an interdisciplinary programme, this one has involved numerous interactions with researchers in a wide range of disciplines. Those most important have been with AgResearch, NIWA, GNS, and the NZ Earthquake Commission (EQC).

David Harte and David Vere-Jones have both been involved in FRST and Marsden projects involving the application of HMM ideas to earthquake occurrence. In particular, David Harte has been exploring properties of an approximate procedure for estimating parameters in the MMPP process. His software package “HiddenMarkov” is available on the Web for simulating and fitting HMM models. Mark Bebbington has been an active collaborator in the inter-institutional group, ‘Volcanic Risk Solutions’, and uses HMM techniques in that context.

An informal Workshop on Hidden Markov Models and Applications was held in the Royal Society’s rooms in Wellington, on 3 September with around 25 people in attendance. The highlight was a talk by the principal invited speaker Professor Walter Zucchini who also held an informal consultation for interested staff and students later that day. He was funded through the link with Statistical Research Associates.

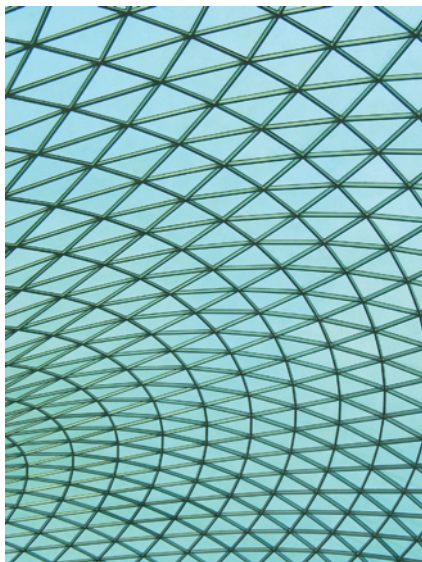
Towards the end of 2007, a young researcher from Athens, Katerina Orfagionnakis, who has applied hidden Markov models to Greek earthquakes, joined the programme. Katerina was funded by her home institution and the NZ Earthquake Commission to work for 3 months with the Wellington group, extending existing applications to more complex models and developing medium term probability forecasts based on the models.

One postdoctoral researcher was involved in the programme during 2008: Dr Jan Bulla, funded by the Deutsche Forschungsgemeinschaft (DFG) from 2007 until he left New Zealand in mid July 2008 to take up a lectureship at the University of Caen in France. During his time in New Zealand, Jan developed new algorithms associated with fitting a general Hidden semi-Markov Models (HSMM), implemented a generic HSMM statistical modelling package in the R language (rather than existing software, which to date had been purpose built for specific applications), and completed two papers in quantitative finance. He also gave a number of conference and other presentations on his work.

Jan Bulla was also introduced to the data and background of the high-frequency rainfall data that formed the focus of the latter part of his stay in New Zealand. This included the modelling of continuous time rainfall data with dynamic time scales that range from minutes through hours and days to months and years. These measurements are recorded at a variety of spatial locations and, in particular, this high-frequency data allows a better understanding of spatial dependence structures in a way that conventional daily rainfall data cannot. The issues involved range from data representation (data sets at different locations need to be put on the same time scale), the need to handle large and complex data sets (this underscores the need for the HSMM analysis package already developed by Jan and his co-workers) and, above all, a suitable multivariate HSMM that both fits the data and throws light on the underpinning physical meteorology involved. Jan has already made a promising start on this very challenging project and others involved in the programme expect to continue this work with him.

Also two research students were involved in 2008:

- Shao-chuan Lv began the final year of his PhD, working with David Vere-Jones and David Harte in Wellington. He has been using the hidden Markov model analysis to further explore the properties of New Zealand deep earthquakes, and has submitted a paper to the Annals of Statistical Mathematics, Japan.
- Ting Wang began the third year of her PhD, working with Dr Mark Bebbington at Massey (Palmerston North), with support from the Marsden Fund. Her work looks at hidden Markov models with covariates, with particular application to earthquake and volcano data. She has also completed a major statistical study of the responses of the Tangshan Well to teleseismic signals, which has been the subject of several conference presentations and was recently submitted for publication.



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There have been significant interactions with researchers at GNS (earthquake risk modelling) and NIWA (rainfall modelling). For NIWA, Dr John Sansom played a major role guiding and assisting Dr Jan Bulla. There were also academic contacts established with VUW statisticians at the Schools of Mathematics, Computer Science and Statistics (SMCS) and Economics and Finance (SEF).

The international status of this programme gained through its commissioning by the NZIMA led directly to the involvement of two high-quality postdoctoral researchers who have now taken up full-time positions in European universities. This has led to enhanced international research and research productivity on nationally important research projects. The programme directors report that “flexible research structures, both funding and academic, are an excellent way of making better use of New Zealand’s limited research statisticians which, with few exceptions, are typically spread over a wide variety of organisations, both academic and non-academic”.

Geometric Methods in the Topology of 3-Dimensional Manifolds

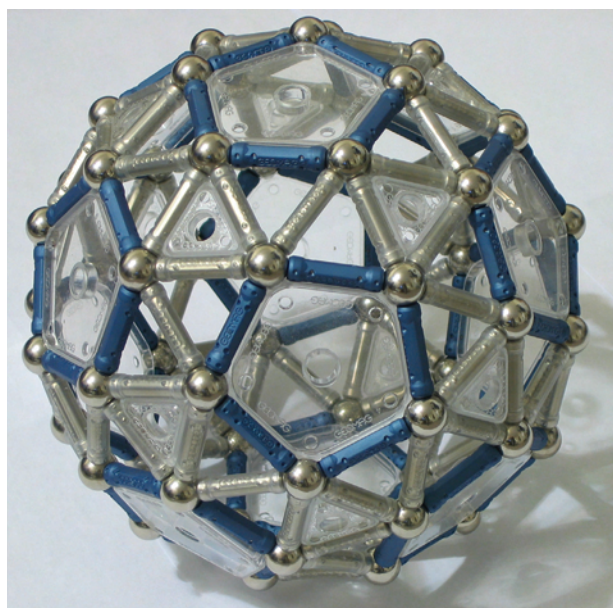
This programme is looking at 3-dimensional manifolds and especially the recent progress resulting from the use of geometry. A particular focus is on the techniques and consequences of recent work on the geometrisation conjecture.

Programme directors: Professor David Gault (University of Auckland), Dr Roger Fenn (University of Sussex) and Professor Vaughan Jones (University of Auckland and University of California, Berkeley).

This programme commenced in January 2006, and is approaching completion and its theme is the study of 3-dimensional manifolds, and especially recent progress resulting from the use of geometry, with focus is on the techniques and consequences of recent work on Thurston's geometrisation conjecture.

- Three postgraduate research students were involved in 2008:
- Stephen Budden is approaching completion of a PhD at the University of Auckland (under the supervision of David Gault), investigating the structure of “quandles”, especially their algebraic properties, and also their uses as knot invariants.
- Qing Zhang has been working for a PhD at Massey University's Albany campus (under the supervision of Gaven Martin), on the space of 2-generator discrete groups of hyperbolic isometries.
- Sunanda Dikshit is working on a PhD at the University of Auckland (under the supervision of David Gault and Sina Greenwood) on differential structures on non-metrisable surfaces.

All three PhD students presented talks on their work at the NZ Mathematics and Statistics Postgraduate Conference in November 2008.



Archimedean Solid or a snub dodecahedron
(Source: Commons Wikimedia)

Partial Differential Equations: Applications, Analysis and Inverse Problems

This programme is devoted to the development of methods for solving partial differential equations (and related “inverse problems”), and the application of these to geothermal modelling, nanotechnology, sea-ice interaction, structural vibration and acoustics.

Programme directors: Dr Colin Fox (University of Otago), Professor Mike O’Sullivan (University of Auckland) and Professor Boris Pavlov (University of Auckland).

This programme commenced in late 2006, and has one more year to run. Two postdoctoral fellows are directly engaged in the programme:

- Dr Al Parker has been working on adapting numerical methods of linear algebra to sampling methods for probability densities, and Gaussian distributions in particular. In 2008 his work uncovered a rich tie between iterative methods of numerical linear algebra and randomised sampling algorithms, and further connections between eigenvalue estimation and the performance of certain sampling algorithms in the presence of round-off errors. The result has been a promising new research direction for numerically stable sampling algorithms that get close to ‘exact’ sampling
- Dr Hyuck Chung (supported by a New Zealand Science & Technology Postdoctoral Fellowship) has been adapting methods developed in the cell-phone industry and in condensed matter physics to improving sound isolation in timber construction. This (perhaps surprising) link arises through the mathematical theory of random matrices. The work is in the early stages, with research directions indicated by numerical experiments that draw heavily on other developments in the programme.

There were also two postgraduate research students involved this year:

- Tiangang Cui is undertaking a PhD on Bayesian methods for inverse problems applied to geothermal model calibration, at the University of Auckland. Tiangang continues to make progress at the leading edge of statistical methods for complex inverse problems. In 2008 he gave an invited presentation at the Complex Computer Models in Sydney. This was an invitation-only workshop for researchers at the forefront of this important new development, chaired by Prof Jim Berger. Tiangang’s work is focusing on novel multi-resolution sampling algorithms, measures of modelling error, and new methods for non-stationary Gaussian processes.
- Erfang Ma is undertaking a PhD at the University of Otago. He has made steady progress on understanding the effect of discretization errors near electrodes in Electrical Impedance Imaging. His results also apply to the modelling of boreholes in hydrological imaging – through the power of mathematical equivalence. He will be talking about his results at an upcoming geothermal workshop.

Two of the three directors of this programme are working in non-mathematics departments (viz. Physics, and Engineering Science). Researchers in this programme routinely interact with non-mathematical disciplines. A major interaction has been with the statistical ‘complex models’ community with developments in treatments for modelling error, and model representation. A significant focus of the programme is applications in geothermal modelling, and building acoustics.

Modelling Invasive Species and Weed Impact

The main aim of this programme (which began in 2006) is the design of a mathematical and statistical framework for exploring the spread and subsequent impact of invading organisms in New Zealand ecosystems, in order to determine the optimal use of resources between the competing demands of controlling existing species and limiting new species, while maintaining biodiversity.

Programme directors: Dr Jennifer Brown, Dr Alex James and Professor David Wall (University of Canterbury).

The programme is involving positive interactions with the BioProtection CoRE, Landcare Research, AgResearch, the Auckland Regional Council, the Canterbury Regional Council, and Environment Southland.

Additional sponsorship has been obtained by the programme organisers from the University of Canterbury, AgResearch, Landcare, and the Miss E.L. Hellaby Indigenous Grassland Research Trust. Generous financial support has been provided by Landcare Research and the Miss E. L. Hellaby Indigenous Grassland Research Trust to support two

David Wall, Jennifer Brown and Alex James



PhD students, while one of the programme's expert visitors (Horst Malchow, Osnabrück, working on invasions in fragmented landscapes) was supported by the University of Canterbury's Erskine fund. In addition, collaboration has taken place with AgResearch (Graeme Bourdôt, Shona Lamoureaux and John Kean) and Landcare Research (Peter Williams) on weed risk assessment, modelling spatial distribution of

weeds, and on assessing national weed distribution data storage systems. Susan Timmins and her co-workers at the Department of Conservation have been working on the problem of dumping of garden waste.

Environment Southland now use a weed surveillance and monitoring system devised by Meghan Williams and Jennifer Brown. This has led to interest for national consistency in weed-distribution data collection, storage and accessibility.

Three postdoctoral fellows were involved in 2008:

- Dr Britta Basse (funded by the University of Canterbury), undertaking research on *Nasella* tussock models, and level set models of weed spread, in close collaboration with AgResearch.

- Dr Richard Brown, working on spatial structure of invasions. He won the best poster prize at the Society for Mathematical Biology meeting Toronto in July/August 2008.
- Dr Joe Stover (funded by the Department of Conservation), modelling dumping of garden waste, in collaboration with the Department of Conservation.

Four postgraduate research students have been engaged in this programme:

- Dawn Lemke is studying for a PhD at the University of Canterbury (with funding from the US), on linking geographic information systems (GIS) with sampling strategies for weed monitoring, in collaboration with the US Forest Service;
- Steve Wangen is studying for a PhD at Lincoln University (with co-sponsorship from the Hellaby Trust and Lincoln University), on modelling weed spread in a heterogeneous environment, in collaboration with the BioProtection CoRE;
- Meghan Williams is studying for a PhD at the University of Canterbury, on linking geographic information systems (GIS) with sampling strategies for weed monitoring, in collaboration with the BioProtection CoRE, Environment Southland and the University of Queensland.
- Kyoko Kukuda is studying for a PhD at the University of Canterbury, on computer enhanced knowledge discovery in Environmental Science.



Alex James being interviewed by John Glass for the MathsReach website

Applications of Mathematics in the Nanosciences

This programme commenced in 2007. Its main focus is on mathematical and computational methods for experimentation with (and model-based prediction of) nanoscale phenomena, and design and control of nanoscale systems. It is a highly multidisciplinary programme, involving interactions between researchers in mathematics, physics, chemistry and engineering.

Programme director: Dr Shaun Hendy (Industrial Research Ltd and the MacDiarmid Institute, Victoria University of Wellington).

The programme's main activity took place in 2007 but a further workshop was held in June 2008 at the University of Lyon (France), with support from the Dumont D'Urville Fund. This workshop was attended by 31 researchers, including three from New Zealand. The workshop's themes included the flow of complex fluids, slip boundary conditions, and both theoretical and experimental nanofluidics. Dr Geoff Willmott (IRL) gave two talks, on the characterisation of resizable nanopores, and on recent work on the transport particles with chemically heterogeneous surfaces ("Janus" particles). The latter talk stimulated considerable discussion, due to the shared interest in surface slip and recent interest in fabrication of Janus particles, leading to the likelihood of ongoing collaboration with the Lyon group. Shaun Hendy from IRL gave a talk on capillary-driven flows in carbon nanotubes.

Dr Geoff Willmott has been collaborating with Australo, which is a Dunedin based company that manufactures resizable nanopores. Geoff is working with Australo to develop techniques for rapid DNA sequencing.

There is continuing interaction with the Christchurch-based firm NanoCluster Devices through its Chief Scientific Officer Simon Brown. The work on coalescence and crystal growth has been of direct relevance to the technology being developed at NanoCluster Devices, and has enabled them to make significant progress in this area.

This has been a highly multidisciplinary programme with interactions with researchers physics, chemistry and engineering, for example on the following projects:

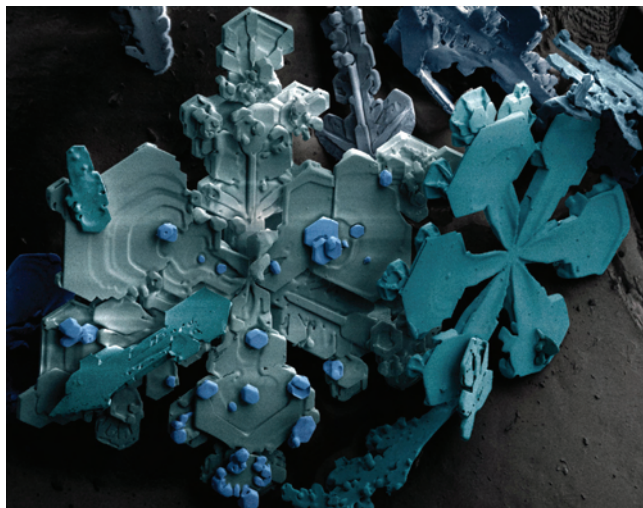
- Melting of nanoparticles (with the theoretical chemistry group at Massey University, and Simon Brown's Physics group at the University of Canterbury)
- Crystal growth and coalescence, using Kinetic Monte Carlo results (with Simon Brown's Physics group at the University of Canterbury)
- Heterogeneous slip boundary conditions (with a number of chemists and physicists, including Drs Catherine Barentin and Dr Cécile Cottin-Bizonne at Lyon).

Sponsorship for this programme has also been received from Dumont D'Urville (enabling us to organise the earlier workshop on nano- and microfluidic flows in April 2007), the Marsden Fund (partial funding for Dmitri Scherbachov), NERF (support for Peter Zoontjens and Sione Paea), the MacDiarmid Institute (hosting the MCN website, providing administrative support for the programme, and funding for David McCarthy and Srikanth Dhondi, as well as travel support for various participants) .

Two Marsden awards were made in 2008 for projects that developed out of this programme: “Are molecular metals like metals or molecules? A case study of superheated gallium clusters” (led by Nicola Gaston), and “What are the correct boundary conditions for fluid dynamics?” (led by Shaun Hendy).

Overseas expert visitors included:

- Prof. Axel Voigt (TU Dresden), who gave a series of seminars at Victoria University of Wellington in March, and has been working on solving surface diffusion problems numerically, including the numerical modelling of nanoparticle sintering (in collaboration with Shaun Hendy and Philip Zhang).
- Prof Tim Schulze (University of Tennessee), who with support from a grant from the US Department of Energy has been hosting Dmitri Schebarchov since August 2008, and collaborating with Shaun Hendy, Peter Zoontjens, David McCarthy and Dmitri on Kinetic Monte Carlo methods.
- Dr Gerald Pereira (CSIRO, Australia), who has been collaborating with Srikanth Dhondi and Shaun Hendy on the flow of complex fluids in nanofluidic devices, with partial funding from the MacDiarmid Institute.



Snow flakes highly magnified by a low-temperature scanning electron microscope (SEM) Source: Commons Wikimedia

Four postdoctoral fellows have been involved, all working with Shaun Hendy at IRL:

- Dr Philip Zhang, working on surface diffusion, melting and homogenization problems. Philip has made some important progress on homogenization of heterogeneous Navier slip boundary conditions in microfluidics.
- Dr Brent Walker (FRST Postdoctoral Fellow), working on calculating the optical properties of semiconductor quantum dots. In 2009 Brent will take up a Fellowship at University College London, in the London Centre for Nanotechnology.
- Dr Nicola Gaston (FRST Postdoctoral Fellow), working on modelling the electro-catalytic behaviour of transition metal carbide catalysts. Nicola won a Fast Start Marsden award (see above), and became a permanent staff member at IRL in 2008.
- Dr Geoff Willmott (FRST Postdoctoral Fellow), working on heterogeneous slip problems related to the transport of colloidal particles. Geoff has published several papers this year on the slip boundary condition.

Five postgraduate research students were engaged in various ways in aspects of this programme, with support from the NZIMA, FRST, the Marsden Fund, and the MacDiarmid Institute for Advanced Materials and Nanotechnology:

- Dmitri Schebarchov (PhD student at VU Wellington) is working with Shaun Hendy on studying the melting of nanoparticles using molecular dynamics and mathematical modelling. Dmitri published several papers in 2008 and was awarded a Fulbright Scholarship to visit Tim Schulze in Tennessee for eight months.
- Jade Mackay is completing his PhD at VU Wellington (with Shaun Hendy), on developing a mathematical model of the growth of zinc oxide nanostructures by electrodeposition.
- David McCarthy has completed a PhD at the University of Canterbury, working with Simon Brown (NanoCluster Devices) and Shaun Hendy (IRL) on the coalescence of nanoparticles using kinetic Monte Carlo.
- Sione Paea began a PhD at VU Wellington in January 2008, working with Shaun Hendy and Mark McGuinness on a multiscale model for the growth of crystals in supersaturated solutions.
- Srikanth Dhondi (PhD student at VU Wellington) is working with Shaun Hendy and Gerald Pereira at CSIRO (Melbourne) on the flow of polymers in nanochannels.



The “honeycomb conjecture” is the idea that a hexagon encloses an area into equal parts with the least perimeter (© iStockphoto.com/ Cimmerian)

Algorithms: New Directions and Applications

This programme commenced in 2008. It centres on the design and analysis of algorithms, and their application to contemporary problems in such areas as discrete mathematics, computational biology, social sciences, and communication networks. Particular attention is being paid to randomized algorithms, approximation algorithms, probabilistic analysis, fixed-parameter tractability, and interaction between these topics.

Programme directors: Professor Mike Atkinson (University of Otago) and Associate Professor Charles Semple (University of Canterbury).

Three main events have taken place so far:

- A week-long meeting on Algorithmics was held in February 2008, at Napier. Invited speakers included Professors Michael Langston (University of Tennessee), Steve Linton (University of St Andrews), Brendan McKay (Australian National University), Michael Mitzenmacher (Harvard University) and Dominic Welsh (University of Oxford). Forty participants (including 14 students) attended short courses of lectures that highlighted the integral role played by algorithmics, from theoretical underpinnings to practical solutions and supercomputers.
- A further short course was held in Christchurch in December. Professor Patrick Morin (Carleton University, Ottawa) gave a series of three informative expository lectures on randomized algorithms.
- A special session on Algorithms was organised as part of the 7th Australia New Zealand Mathematics Convention, also in Christchurch in December. Invited speakers were Professor Mike Atkinson (University of Otago), Dr Michael Dinneen (University of Auckland), Professor Rod Downey (Victoria University Wellington), Associate Professor Graham Farr (Monash University), Dr Joachim Gudmundsson (National ICT, Australia), Associate Professor Gordon Royle (University of Western Australia), Associate Professor Charles Semple, and Professor Toby Walsh (National ICT Australia and University of New South Wales).

Professor Steve Linton (University of St Andrews) visited the University of Otago in February and March, and this visit initiated a research project involving both Mike Atkinson and Michael Albert, as well as Prof. Julian West (Victoria University, Canada).

Also in February and March, Professor Dominic Welsh (University of Oxford) visited Victoria University of Wellington, where he worked with Dillon Mayhew, Mike Newman and Geoff Whittle, and the University of Canterbury, where he worked with Charles Semple and PhD student Beata Faller.



Alex Raichev, postdoctoral fellow on the Algorithms programme

This programme is supporting two postdoctoral fellows:

- Dr Alex Raichev (University of Auckland) is working on asymptotics of multivariate generating functions, until April 2009
- Dr Chris Dowden (University of Canterbury) began working on algorithmic problems in phylogenetics, at the end of October 2008.

The programme has also engaged three postgraduate students:

- Reyhaneh Reyhani (PhD, University of Auckland), on computational social choice
- Josh Collins (MSc, University of Canterbury), on algorithmic aspects of reticulate evolution
- Beata Faller (PhD, University of Canterbury), on algorithmic problems in conservation biology.

Mike Atkinson organised a conference on Permutation Patterns at the University of Otago in June 2008. Among the combinatorialists who attended were Michael Albert (Otago), Julian West (Victoria University, Canada), and Robert Brignall (Bristol University, UK), all of whom are involved with algorithmic aspects of permutation problems.

Charles Semple and Mike Steel organised a special session on Mathematics of Evolution and Ecology as part of the 7th Australia New Zealand Mathematics Convention, at the University of Canterbury in December 2008. Many of the attendees of the Algorithmics special session also attended this session.

This programme has benefited through co-sponsorship from the Department of Computer Science at the University of Otago and the Marsden Fund.



Geoff Whittle being interviewed by John Glass for MathsReach

Conformal Geometry and its Applications

This programme commenced in 2008. Its themes are conformal and hyperbolic geometry; symmetries and natural geometric equations; invariants and applications; and nonlinear elasticity and materials science.

Programme directors: Dr Rod Gover (University of Auckland) and Professor Gaven Martin (Massey University).

The programme's main meeting, on conformal geometry and geometric approaches to partial differential equations, took place in Nelson in January 2008. Its principal themes were the use of conformal geometry and related techniques to study geometric and topological properties of manifolds and the use of geometric approaches to study partial differential equations. The meeting attracted over 40 participants including a dozen students from New Zealand and overseas. Most of the talks were pitched at an ideal level for an introduction to the area. It featured outstanding researchers, each giving a series of lectures surveying recent developments in the area:

- Ian Agol (UC Berkeley), Future Directions in 3-Manifold Geometry and Topology
- Alice Chang (Princeton University), Elliptic PDE in Conformal geometry
- Michael Eastwood (University of Adelaide), Symmetries and Prolongations of PDE: Symmetries of the Laplacian, Conformal Killing Equations via Prolongations, and General Theory of Prolongations
- Robin Graham (University of Washington), Introduction to Conformal Geometry; the Weyl Curvature Tensor; Characterization of Conformal Flatness, and the Ambient Metric, Tractor Bundle & Connection
- Claude LeBrun (Stony Brook University, New York), Einstein Metrics and Global Conformal Geometry
- Willard Miller, Jr. (University of Minnesota), LI: Planetary motion, the hydrogen atom and superintegrability; Structure and classification results for second order superintegrable systems; Models for irreducible representations of quadratic algebras
- Neil Trudinger (Australian National University), Glimpses of non-linear PDE in the 20th century
- Paul Yang (Princeton University), The Q-Curvature Equation in Conformal Geometry.

A research workshop on Parabolic Geometry was held in August 2008 at the University of Auckland. This attracted around 30 participants including eight students, and formed part of a focussed research period on parabolic geometry, PDE and prolonged systems that took place from July to September. The aim of this period was to progress several closely related areas of geometry and the geometric approaches to PDE. The activity comprised informal seminars and working groups involving New Zealand and international participants, and was co-sponsored by the Marsden Fund awards, Massey University, and the University of Auckland. In particular, this sponsorship covered the costs of visiting experts Robert Bryant (MSRI Berkeley & Duke University, USA), Maciej Dunajski (University of Cambridge), and Paul Baird (University of Brest, France).

Additional visiting experts during 2008 included Andreas Juhl (Humboldt University, Berlin), Kari Astala (University of Helsinki) Josef Silhan, (Masaryk University and International School for Advanced Studies), and Trieste Eugene Poletsky (Syracuse University, New York).

The programme has engaged a number of research students, some of whom are supported by the Marsden Fund or the University of Auckland:

- Niels Bernhardt (PhD, University of Auckland), working on the classification of holonomy groups of spinorial connections
- Howard Cohl (PhD, University of Auckland), working on special functions and explicit constructions of fundamental solutions for geometric PDEs
- Haydn Cooper (PhD, Massey University), working on computational conformal geometry; Haydn has implemented an alpha version of his adaption of the computational geometry programme Snappea, and this is currently being refined so as to attack the problems and questions that will be the focus of his PhD project
- Maarten Jordens (PhD, Massey University), working on conformal geometry and non-linear materials science
- Geon Oh (MSc, University of Auckland), working on linear connections, their curvature and special frames
- Callum Sleight (MSc, University of Auckland), working on the geometry of PDEs via Spencer theory
- Heather Macbeth (BSc(Hons), U Auckland), who undertook a project on conformal and projective geometry.
- Matthew Randall, (BSc(Hons), U Auckland), who undertook a project on Lie algebras and conformally invariant operators.

The programme is also supporting one postdoctoral fellow: Dr Paul-Andi Nagy (University of Auckland), who is working on special structures and natural differential operators, conformal techniques, Lie algebra prolongations, and applications.



Maarten Jordens, student on the programme

Energy, Wind and Water

This (partial) programme involves the use of cross-disciplinary approaches to model and analyse the natural resources of energy, wind and water. Such approaches combine simulation techniques with optimization algorithms to improve engineering designs, or with control algorithms to improve operations.

Programme director: Professor Mike O'Sullivan (University of Auckland)

This programme began in late 2008 and is continuing to 2011.



Mathematical & Statistical Knowledge for Teachers at Senior Levels

This (partial) programme is investigating the mathematical conditions in the last years of schooling and undergraduate courses in New Zealand that are needed to ensure the provision of a sufficient flow of competent graduates to meet the needs of all sectors of society that require mathematical knowledge and abilities beyond Year 11 levels.

Programme director: Associate Professor Bill Barton (University of Auckland)

This programme began in late 2008 and is continuing to 2011.



MACLAURIN FELLOWS

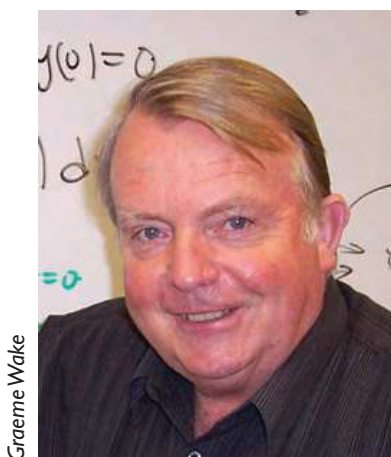
Full year Maclaurin Fellows

Prof. Graeme Wake (Massey University)

Graeme completed his year as a Maclaurin Fellow at the end of February 2008. The focus of his research was on the underlying theory and structure associated with functional differential equations where cause and effect are separated in space, size, and/or time, and so on. These exemplify a rich structure and usually are difficult to solve; they arise in a diverse range of applications, and yet there is little generic theory. The work proceeded in two related streams in parallel: (a) non-local “spatially-structured” equations and spectral theory, and (b) delay and distributed-delay differential equations (DDDEs).

In joint work with Professor David Wall (University of Canterbury) and research fellow Dr Ronald Begg (Massey University), Graeme achieved a raft of results on the spectrum of non-local singular Sturm-Liouville eigenvalue problems on a semi-infinite interval, which generalise those known for purely local ones on a finite interval and on an infinite interval (the classical cases). The interesting general outcome is that the non-local singular Sturm-Liouville eigenvalue problem in a wide number of cases has a countably infinite number of discrete eigenvalues. This is startling, in that the non-local term re-introduces a point spectrum, in contrast to similar problems arising from earlier cell-growth models.

Graeme was also involved as an associate investigator in another of the CoREs, the National Research Centre for Research and Development (NRGCD), and has undertaken some joint work with Peter Gluckman and others on a stochastic model for optimising phenotype plasticity. In September, Graeme Wake and Tony Pleasants (AgResearch) gave a presentation at the annual meeting of the NZ Association of Mathematics Teachers, on “Mathematics in Medicine and Agriculture”. In addition, Graeme continued his work for the Centre for Mathematics in Industry at Massey University, helping to organise focused special in-house working parties, with support from FRST’s Technology Expert scheme, on projects with Hygiene Systems Ltd and Fisher & Paykel Ltd.



Graeme Wake

Professor Eamonn O'Brien (University of Auckland)

Eamonn O'Brien began his year as a Maclaurin Fellow in July 2008, following his terms as an invited member of a programme at the MSRI (Berkeley, USA) on "Representation Theory of Finite Groups and Related Topics" earlier in the year.

An early highlight has been his joint work with Martin Liebeck (Imperial College), Aner Shalev (Hebrew University) and Pham Huu Tiep (Arizona), in which they completed verification of the long-standing Ore conjecture: namely, that every element of a non-abelian finite simple group is a commutator. They have written up this work in an 80-page paper for publication.

A further significant piece of research involves joint work with Prof. Charles Leedham-Green (Queen Mary, University of London), on constructing short presentations for the classical groups of Lie type. Such presentations are of both theoretical and practical interest, particularly in seeking to verify the putative chief series for a linear group.

Other projects have involved joint work with Dr Henrik Baarnhielm (a postdoctoral fellow at the University of Auckland), on the development and implementation of Monte Carlo algorithms to construct a chief series for a linear group, and Professor Mike Newman (Australian National University), on the structure of odd order p -groups of fixed co-class.



Eamonn O'Brien

Short-term Visiting Maclaurin Fellows

Prof. Edgar Knobloch (University of California at Berkeley)

Edgar Knobloch was appointed as a Visiting Maclaurin Fellow for an 11-week period from August to October 2008. During this time he engaged in research (and research discussions) with several members of the Mathematics Department at the University of Auckland, including the following:

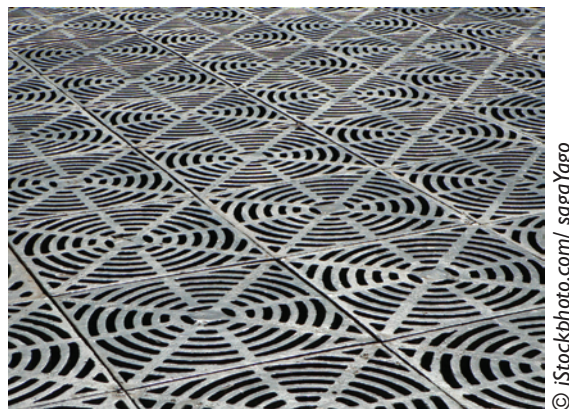
- Dr Vivien Kirk, on dynamical systems – specifically the dynamics occurring near a heteroclinic cycle between a hyperbolic equilibrium and a hyperbolic periodic orbit
- Dr Mike Meylan, on the dynamics of long waves on ice-covered water, and the possibility that these can be described by a Korteweg-de Vries type of equation with higher order dispersion arising from the elasticity of the ice sheet
- Prof. James Sneyd, on propagating pulses in a class of reaction-diffusion equations
- Two students of Vivien Kirk and a postdoctoral fellow (Dr Amanda Elvin), about their research projects.

In addition to this work he gave lectures on “Spatially localized structures in dissipative systems” and “Spatially localized patterns”.

Michael Eastwood (Australian National University)

Michael Eastwood was appointed as a Visiting Maclaurin Fellow, for a short visit in January and a month-long visit in August 2008.

During these visits he engaged in research with Prof. Rod Gover (University of Auckland) on the prolongation of contact structures, also had extensive discussions and engaged in research collaboration with a number of the other participants on the Conformal Geometry programme (including Robert Bryant and Maciej Dunajski).



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RESEARCH BY CO-DIRECTORS

Professor Marston Conder has been continuing his research (supported also by the Marsden Fund) which is principally in combinatorial and computational group theory, with applications to the study of discrete objects with maximum symmetry. A particular recent highlight has been his work with Jozef Siran (ex-Auckland, now in the UK) and Tom Tucker (New York) in using group-theoretic techniques to analyse the genus spectrum of various kinds of symmetric embeddings of graphs on surfaces (known as regular maps). His recent discoveries, resulting from patterns in computational data, are being regarded as among the greatest breakthroughs in the study of regular maps in the last century. In 2008 he has continued to make further discoveries in this area, including fundamental observations about regular Cayley maps (in joint work with Tom Tucker), and regular embeddings of n -dimensional cubes (in joint work with Dominico Catalano (Portugal), Young Soo Kwon (Korea), Steve Wilson (Arizona) and others). In addition in 2008, he served as President of the Academy and Vice-President (International) of the Royal Society of New Zealand, and as a member of the NZ National Science Panel.



Marston Conder

Professor Vaughan Jones has been involved recently in several inter-related research projects. Perhaps the most novel is the work with Alice Guionnet, in trying to use a modified version of Conway's skein theory to construct matrix models that may be solved using planar algebra techniques. The first case of this is the skein theory underlying the Jones polynomial, which allows one to use an arbitrary Temperley-Lieb four point tangle as a quartic perturbation to a Gaussian. They have used the Schwinger-Dyson equation to obtain an algebraic relation for the generating function of the expected value of certain words, which suffices to determine the partition function. Further, in joint work with Dima Shlyakhtenko they are deepening their understanding of the graded and shifted grade algebras associated with a planar algebra. The introduction of the 'corner' element allows for a simple computation of the index of the relevant subfactor, and introduces type III factor structure, which should be revealing in understanding the elusive connection between the hyperfinite and non-hyperfinite versions of the construction.

Work continues on the free product of two planar algebras (or free composition of the subfactors). This is to be applied in investigations of several intermediate subfactors whose invariants become algebras over a planar operad enriched by the Fuss-Catalan structure. The first application would be to classify annular Fuss-Catalan representations, and use them to construct subfactors with an intermediate subfactor (the existence of which has been conjectured by Bisch and Haagerup).

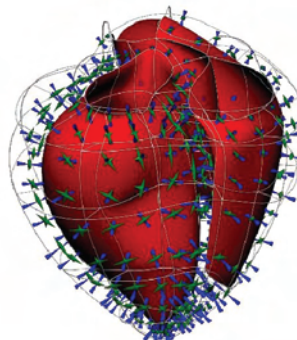


Vaughan Jones

RESEARCH BY POSTGRADUATE STUDENTS

In addition, the following postgraduate research student projects were supported by the NZIMA in 2008 (based on the merit of the student and the value of their project):

- Robin Averill (Victoria University of Wellington), PhD in mathematics education
- Jonathan Crook (Victoria University of Wellington), PhD on modelling sea-ice
- Tiangang Cui (University of Auckland), PhD on geothermal model calibration
- Blaise Drinkwater (Victoria University of Wellington), Masters project on randomness
- Michael Hayward (University of Canterbury), Masters project on population estimation
- Maarten Jordens (Massey University), PhD on distortion functionals and variations
- Javad Khazei (University of Auckland), PhD on system integration of wind farms via stochastic optimisation
- Joshua Koh (University of Auckland), Masters project on flow in petroleum reservoirs
- Xinshan Li (University of Auckland), PhD on modelling childbirth
- Jing Liu (University of Auckland), PhD on New methods for estimating effective population size, N_e
- Kim Noakes (University of Auckland), Masters project on a computational model of the male and female pelvic floor regions
- Dion O'Neale (Massey University), PhD in geometric numerical integration
- Vicki Wang (University of Auckland), PhD on modelling of Left Ventricular Disease
- Lei Zhang (University of Auckland), PhD on optimisation of ambulance relocation and dispatch
- Yue Zhao (Massey University), Masters on transmission of a virus on a structured population
- Qizhi Zhou (University of Waikato), PhD in number theory
- Tong Zhu (University of Auckland), PhD on optimal control and phase transitions in stochastic networks.



A finite element model of the heart
used in studying heart failure

CONFERENCES, PUBLIC EVENTS AND OTHER ACTIVITIES

We used the NZIMA's CoRE funding and status to lend support to the following conferences held in New Zealand in 2008:

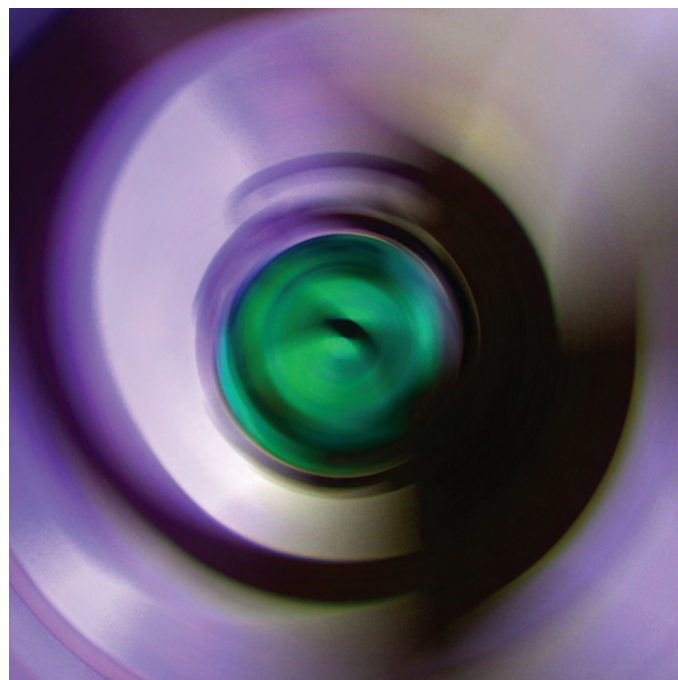
- A 3-day Workshop on Multi-scale Modelling of the Respiratory System was held at the University of Auckland, in February. This meeting brought together 70 mathematicians, engineers, physiologists and medical researchers, including 45 from New Zealand and others from the US, France, Australia, the UK, Canada, Ireland, Slovenia and Germany. The workshop was co-sponsored by Fisher & Paykel Healthcare and Philips Medical, and its organiser Alona Ben-Tal (Massey University) was pleased to see it stimulate several new collaborations for NZ-based researchers, modellers and medical researchers.
- A Workshop on Permutation Patterns, Dunedin, June 2008; see the report on the NZIMA programme on Algorithms (in Section VIII).
- The second New Zealand Mathematics & Statistics Postgraduate Students Conference was held at Whitianga, for three days in November 2008. The conference attracted 63 postgraduate students, from all over New Zealand, and the talks they presented on their research spanned a diverse range of topics, from representation theory to queueing theory, and phylogenetics to topology. Mareike Fischer (U Canterbury) won the NZIMA's Best Presentation award, for her talk on "Why DNA sequences can be perfectly misleading, and Peter Humphries (U Canterbury) won the Peoples' Choice Award (sponsored by Hoare Research Software) for his talk on "Nesting polynomials in infinite radicals". The meeting was organised by Howard Cohl and Alethea Rea (U Auckland), with help from Haydn Cooper, Maarten Jordens and Dion O'Neale (Massey U), Beata Faller (U Canterbury) and Lyndon Walker (U Auckland).
- A 5-day conference on Finite Groups and Representations was held at the Edward Percival field station in Kaikoura in January 2008. Among the highlights were the talks of Martin Liebeck and Gary Seitz on their classification of unipotent classes in simple algebraic groups, which provides an explicit algorithmic solution of an important problem in algebraic groups and representation theory. The meeting attracted 26 participants, from New Zealand, Australia, Europe and the US, including six students, all of whom benefitted from hearing the latest developments in the area. The meeting also helped initiate several new research collaborations.
- A half-day workshop for women researchers in the mathematical sciences was at the University of Canterbury in December, preceding the 7th Australia New Zealand Mathematics Convention. There were 25 participants, of which 17 were PhD students and the rest were mostly earlier career researchers. The workshop (organised by Vivien Kirk (Auckland) and Alex James and Clemency Montelle (Canterbury) on behalf of the NZIMA) was based around two formal sessions, one on "Surviving a Conference" (presented by Vivien Kirk and Ilze Ziedins) and the other a presentation by Dr Susan Timmins from the Department of Conservation about her experiences as a professional scientist in NZ. In addition, the workshop included informal activities that provided a basis for informal networking and mentoring.

The workshop was appreciated by the participants, and has clearly helped young women mathematicians establish a community for themselves within the larger mathematical world. It has also provided a good example for a similar workshop for women now being organised for the next annual meeting of the Australian Mathematical Society.

- The NZIMA was a major sponsor of the 7th Australia New Zealand Mathematics Convention, held at the University of Canterbury, during the week 8-12 December 2008. This event, in a series of joint conferences held every four years, attracted 303 participants (to our knowledge, the largest ever meeting of mathematicians in New Zealand). The programme featured 10 plenary lectures, and approximately 250 other presentations, in 16 special sessions. The Convention was a spectacular success: the research of New Zealand mathematical scientists was showcased to an international audience, and world-class plenary lecturers spoke about exciting new developments in their subjects. Other highlights included: a diverse display of high-quality books by Springer-Verlag; New Zealand students winning the both local and Australian prizes for best student presentations; well attended social functions and excursions providing opportunities for networking with international researchers.

Public Events

The NZIMA sponsored several public lectures in 2008, some in collaboration with the University of Auckland's Mathematics Department. In particular, a number of lectures were given by Professor Peter Cameron (Queen Mary, University of London) at university centres around New Zealand in April. Peter Cameron was visiting as the London Mathematical Society's Forder Lecturer for 2008 (made possible from a bequest to the LMS by Henry George Forder, who was Professor of Mathematics at the University of Auckland from 1934 to 1955). One of his lectures was entertainingly titled "Sudoku: Is it Mathematics?". He was also interviewed by Kim Hill on National Radio.



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AWARDS AND HONOURS

The following is a selection of awards and honours won by NZIMA people in 2008:

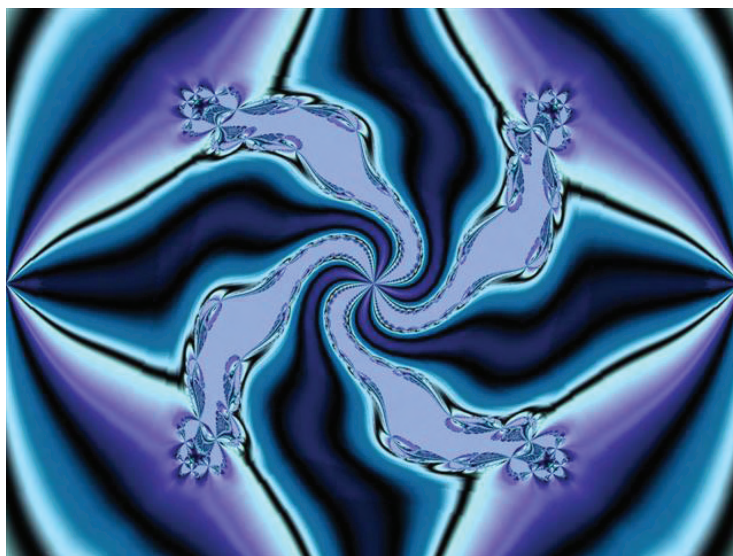
- Bill Barton (Director of our new programme in Mathematics Education) has been elected the next President of the International Commission on Mathematical Instruction (ICMI), from 2010 to 2012. This is a significant honour, made all the more notable given that 2008 is ICMI's centenary year.
- John Butcher (one of the NZIMA's PIs and director of one of our first programmes, on Numerical methods for Evolutionary Problems) was awarded a prestigious Honorary Fellowship of the European Society of Computational Methods in Sciences and Engineering, "for his outstanding contribution in the field of Computational Mathematics and Numerical Analysis". In addition, his 75th birthday was honoured at a conference in Greece.
- NZIMA Co-Director Marston Conder became the Royal Society of New Zealand's first Vice President International, after completing a term as President of the RSNZ Academy
- Mike Eastwood, one of our Visiting Maclaurin Fellows for 2008, won a Federation Fellowship from the Australian Research Council
- Rod Gover (Co-Director of our programme in Conformal Geometry) was invited to be a Member of the Institute of Advanced Study, Princeton, for a half-year period in 2008; he is the only New Zealander in recent history to win this honour.
- Mike Hendy, another of the NZIMA's PIs, won two awards in 2008: a New Zealand Science & Technology Medal from the Royal Society of New Zealand, and the NZ Mathematical Society's annual Research Award. These awards recognise Mike's seminal work on mathematical approaches to molecular ecology and evolution, and the quantitative methodology that forms an integral part of phylogenetic software used worldwide.
- Shaun Hendy, director of our programme on Applications of Mathematics in the Nanosciences, has been appointed Deputy Director of the MacDiarmid Institute for Advanced Materials and Nanotechnology.
- Ross Ihaka (University of Auckland), whose development of the "R" system was featured in issue 3 of our NZ-IMAgEs magazine, was awarded the Pickering Medal of the Royal Society of New Zealand at the NZ Science Honours Dinner in Wellington



Ross Ihaka, whose development of "R" was featured in Issue Three of NZ-IMAgEs

in November. The Pickering Medal, which recognises excellence and innovation in practical applications of technology, is one of the three premier awards made by the RSNZ at the annual dinner.

- NZIMA co-director Vaughan Jones gave an invited lecture on the Poincare conjecture and the Riemann hypothesis at a symposium of Rutherford Medal winners in Dunedin on 3rd December. (Vaughan was in fact the first ever winner of the Rutherford Medal, in 1991.) See: www.odt.co.nz/on-campus/university-otago/34559/top-scientists-gather-dunedin.
- Gaven Martin (one of the NZIMA's principal investigators, and co-director of our programme on Conformal Geometry) was awarded the Hector Medal for 2008 by the Royal Society of New Zealand. This is one of the RSNZ's longest-standing medals, and is now awarded every three years in mathematical and information sciences, to a researcher who has undertaken work in New Zealand of great scientific or technological merit and has made an outstanding contribution to the advancement of these branches of science.
- Nic Smith, director of one of our first programmes (on modelling cellular function), has been appointed to a chair in Computational Physiology at the University of Oxford, and has been invited to co-direct a programme on "The Cardiac Physiome Project: mathematical and computational foundations" at the Isaac Newton Institute (Cambridge, UK) from June to August 2009.
- Vicky Wang (an NZIMA-sponsored PhD student) won the Young Investigator Award in the modelling category at the 11th MICCAI Conference 2008 in New York city, for her paper on "Passive Left Ventricular Mechanical properties estimating using Cardiac MRI".



Fractal Art Kompas.jpg (Source: Commons Wikimedia)

INTERNATIONAL LINKAGES

The NZIMA is a member of the International Mathematical Sciences Institutes (IMSI), an international consortium of research institutes in the mathematical sciences that run thematic programmes and have large visitor programmes, and is listed on the IMSI website:

www.fields.utoronto.ca/aboutus/IMSI.html

The NZIMA is a founding member of the new Pacific Rim Mathematical Association (otherwise known as 'PRIMA'), established at the end of 2005 with the aim of promoting and facilitating the development of the mathematical sciences throughout the Pacific Rim region. This new consortium of mathematical sciences institutes will involve improved networking, coordination of activities, training (including summer schools), infrastructural assistance, sharing of expertise, and pooling of resources. Marston Conder is a member of PRIMA's Liaison Committee. More information about PRIMA and its intended activities can now be found on its website <http://www.primath.org/>. One forthcoming initiative is a Pacific Rim Mathematical Congress, to be held in Sydney Australia in July 2009.



Communication linkages with institutes overseas have been set up through visits by one or both of the two Co-Directors (often while attending other conferences). These include the Fields Institute in Ontario, the Mathematical Sciences Research Institute (MSRI) in California, and the Pacific Institute of Mathematical Sciences (PIMS) in British Columbia.

Very strong international linkages have been developed by the NZMRI through its earlier programme of annual summer workshops, and these are being taken further by the involvement of invited overseas experts in NZIMA programmes and as visiting Maclaurin Fellows.

The NZIMA's website, the quarterly e-mail newsletter and our new NZ-IMAgEs bulletin (sent to a large number of people overseas) are proving useful devices for maintaining and enhancing international contacts.

Strong and productive international linkages are also being maintained through the NZIMA's International Scientific Advisory Board, which includes a number of representatives from other members of the IMSI (such as the CMA, MSRI and PIMS), as well as prominent New Zealand-born mathematical scientists and others resident overseas.

GOVERNANCE AND MANAGEMENT

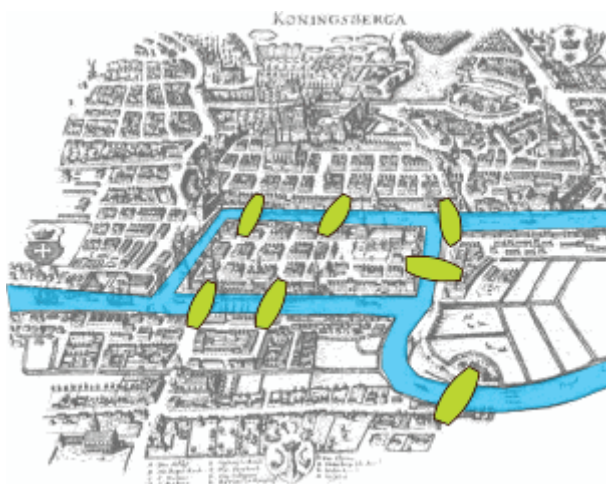
The NZIMA's current Governing Board met for the last time in March 2008. A new board is currently being configured. Key ongoing challenges for this new board are to formulate strategies for the NZIMA to build its activities, funding, profile and outreach, with the additional challenge of dealing with the outcome of the 2006/07 CoRE selection round.

Our Advisory Board assists the NZIMA by providing advice when requested on the selection of thematic programmes and other important decisions.

Members of our Executive Committee (Rod Downey, David Ryan and Graham Weir) and other ad hoc committees assist the two Co-Directors in making decisions about activities for support using CoRE funds, including the selection of thematic programmes, Maclaurin Fellows, postgraduate scholars, and other activities for support.

The two Co-Directors are interacting with executives of other CoREs in New Zealand and in other mathematical sciences institutes overseas to help develop future strategies and explore opportunities for closer interaction. For example, the NZIMA is helping to promote and facilitate the development of the mathematical sciences throughout the Pacific Rim region through its membership of the Pacific Rim Mathematical Association (PRIMA).

Our Research Manager assists the two Co-Directors, Maclaurin Fellows and programme directors with administrative and financial matters, including annual reports, website development and organisation of conferences/travel, and produces a quarterly newsletter on the NZIMA's activities. She also project manages the production of our newsletter, NZIMAgés and items for our schools' website, MathsReach.



The Seven Bridges of Königsberg is a famous historical problem in mathematics. In 1736 Leonhard Euler proved there was no solution. This is the foundation of graph theory and a precursor to the field of topology (Source: Commons Wikimedia)

FINANCIAL STATEMENT

This report covers only the activities supported by the award to the NZIMA from the Centres of Research Excellence (CoRE) Fund.

Statement of Financial Performance for the 2008 year

Income	Actual	Budget	Variance
CoRE Funding	\$ 1,019,445	\$ 1,427,222	\$ *(407,777)
Host/Partner Support	1,867	0	1,867
Total Income	\$ 1,021,311	\$ 1,427,222	\$ (405,991)
Expenditure	Actual	Budget	Variance
<i>Salaries</i>			
Director & Principal Investigators	\$ 76,134	\$ 81,250	\$ 5,116
Associate Investigators	96,102	175,700	79,598
Postdoctoral Fellows	264,288	192,500	(71,788)
Research/ Technical Assistants	15,000	15,000	0
Others	33,021	27,375	(5,646)
<i>Total Salaries (a)</i>	<i>\$ 484,545</i>	<i>\$ 476,825</i>	<i>\$ 7,280</i>
<i>Other Costs</i>			
Project Costs	\$ 155,606	\$ 102,167	\$ (53,440)
Travel	63,666	80,000	16,334
Postgraduate Student Support	552,380	215,656	(336,725)
Indirect Costs: Overheads	317,485	506,575	189,090
Equipment depreciation	0	0	0
Rental - equipment	613	35,000	34,387
Subcontractors	0	0	0
Extraordinary expenditure	0	11,000	11,000
<i>Total Other Costs (b)</i>	<i>\$ 1,089,750</i>	<i>\$ 950,397</i>	<i>\$ (139,353)</i>
Total Expenditure	\$ 1,574,295	\$ 1,427,222	\$ (132,073)

Statement of Financial Position as at 31 December 2008

	Previous total	Current year	Nett total
Funds committed but not yet spent	\$ 1,792,185	\$ (552,984)	\$ 1,239,201
Represented by			
Thematic programmes 2007/08/09			\$ 681,901
Maclaurin fellowships 2008/09			79,000
Postgraduate scholarships 2007/08/09			478,300
Total commitments going forward			\$ 1,239,201

* Compensating for additional out-of-cycle payment in 2007

RESEARCH PUBLICATIONS

The following is a selection of publications in 2008 by researchers supported by or involved with the NZIMA during recent times. Note that many of these will also appear in the lists of publications of other Departments or Centres/Institutes in the University of Auckland, or in those for some other New Zealand universities.

Articles in Refereed Journals and Refereed Conference Proceedings

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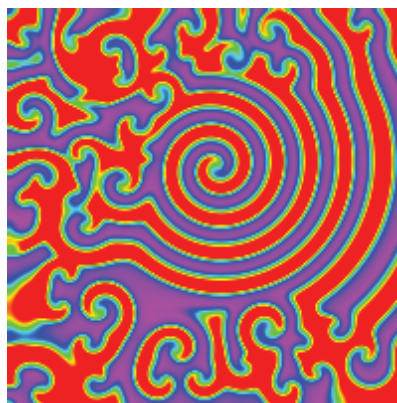
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Simulation of calcium waves in cells