

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

ANNUAL REPORT for the year 2007

**Approved by the NZIMA Governing Board
on 17 March 2008**

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OVERVIEW FROM CHAIR OF THE NZIMA BOARD

Sir Ian Axford DSc FRS FRSNZ, Chair of the NZIMA's Governing Board, reports:

Once again I am delighted to present the annual report of the New Zealand Institute of Mathematics and its Applications (the NZIMA), on behalf of its Governing Board.

The year 2007 has been one of great heights and great depths. It has seen the NZIMA continue to mature, building on its already impressive international reputation in the mathematical sciences, achieving beneficial outcomes for New Zealand and communicating much of what it does to the wider scientific and educational community. I am consistently amazed at how many stakeholders the NZIMA manages to reach in its work.

However, despite an outstanding international reputation, unprecedented support from university departments and professional societies in New Zealand, 2007 was also the year that the NZIMA's application to the Tertiary Education Commission for a further six years of Centres of Research Excellence status and funding was turned down. This was a crushing disappointment for the entire mathematical sciences community in 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 that it epitomises excellence.

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.

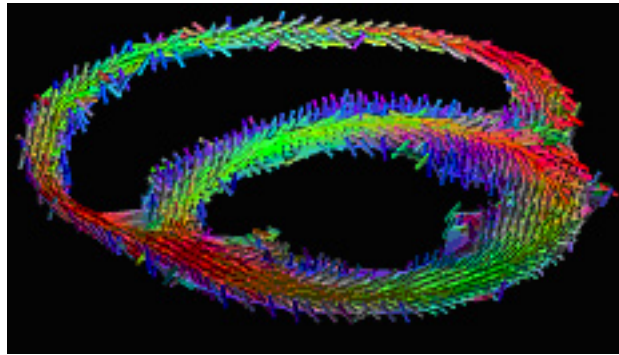
This excellence has not, however, been confined to particular areas of the discipline — wonderful outcomes are being seen in both fundamental and applied aspects of the mathematical sciences, very positive interactions with a wide range of other disciplines (including biology, computer science, ecology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

It is clear that the principals 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 — prime among these being its new initiatives such as the NZ-IMAgEs bulletin and the MathsReach resource for schools. This latter, which had its official launch in February, with the Prime Minister in attendance, has won acclaim and appreciation from teachers and parents around New Zealand.

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

I congratulate 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. Despite its failure to gain a further six years of CoRE funding, there is no doubt in my mind that the NZIMA is pursuing the goals of the Centres of Research Excellence Fund in outstanding fashion.

A reconfigured Governing Board will continue to play its role in the development of the NZIMA, and to shape its strategy in the years ahead. We look forward to its continued success over the next three years, and hopefully to further support in the future.



Three dimensional rendering of myocardial fibre vectors

REPORT FROM DIRECTORS AND EXECUTIVE COMMITTEE

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

A highlight was our launch in February 2007 of a new outreach initiative, called “MathsReach”. The aim of MathsReach is to provide resources to help school teachers and students (and their parents and career advisers) see what lies beyond the school

Students at the MathsReach launch



curriculum in mathematics and statistics — in terms of professional careers, research activity, hot topics, and interesting and important applications. This is being achieved through a variety of media (video clips, web links and special articles), with a focus on people and what they do. For example, it contains an interview with Vaughan Jones, who describes how his fundamental discoveries about polynomial invariants of knots arose by accident from his

research in quantum theory, and how they relate to questions in cell biology. Other interviews include one with Jennifer Brown (University of Canterbury), who talks about the use of statistical methods in New Zealand ecology, and another with Marcus du Sautoy, who describes the music behind the randomness of prime numbers and how primes are used to keep money and other details secure during internet transactions.

MathsReach was officially launched by the Prime Minister, the Rt. Hon. Helen Clark, at Onehunga High School on 23rd February 2007. It has been made available on a website (www.mathsreach.org) and as a CD/DVD, free of charge to schools. The launch on 23rd February marked the first step in its

development; resource material on the web and the CD/DVD will be supplemented and updated over time. To follow up on this new initiative, we appointed Judy Paterson as a schools liaison person for 2007, on a part-time basis (jointly with the University of Auckland’s Mathematics Education Unit).



Marston Conder and the Prime Minister

At about the same time we published our second issue of “NZ-IMAgEs”, a glossy bulletin of news and activities associated with the NZIMA, for wide distribution and further outreach — particularly to schools. NZIMAgEs has won a lot of interest and wide acclaim from teachers and others in the mathematical sciences community. Two issues are produced each year. See www.nzima.org/Publications.html.

The year 2007 began for us in early January with a summer meeting at Waitangi, held as part of our thematic programme on Partial Differential Equations. Excellent lectures were given by several experts in the field, and the workshop established a strong basis for three important projects that the programme is pursuing (in geothermal model calibration, inference in electrical impedance tomography, and mid-frequency sound transmission in lightweight timber framed structures).

January also saw the start of a highly successful series of public lectures around New Zealand, as follows:

- John Conway (Visiting Maclaurin Fellow, and also Distinguished von Neumann Professor at Princeton University) on “The Game of Life”, at the University of Auckland in January;
- Marcus du Sautoy (Visiting Maclaurin Fellow), on “The Music of the Primes”, in Christchurch in February, and in Auckland in March; Marcus du Sautoy was interviewed by Kim Hill on National Radio in March;
- Vaughan Jones (NZIMA Co-Director), on “Flatland - a great place to do algebra”, at Victoria University of Wellington in March, and at the University of Auckland in December;
- Charles Leedham-Green (University of London), on “Newton’s Principia”, at the Auckland Museum, in April;
- Ian Stewart (University of Warwick), Seelye Fellow, on “All the World’s a Network”, at the University of Auckland in October and on “The Pattern of Tiny Feet” (the 2007 Archey Lecture) and “The Mathematics of Evolution”, at the Auckland Museum in October.



Marcus du Sautoy

The NZIMA facilitated a pioneering event on 5th February 2007: Paul Bonnington (Co-director of our Combinatorics programme, and leader of the “BestGrid” project in New Zealand) organised an interactive seminar using the new AccessGRID technology, in which Mike Steel (of the NZIMA and the Allan Wilson Centre) gave a talk on “Ancestral networks, and the curse of the unfaithful grandparents”, simultaneously at the University of Auckland and the HitLab at the University of Canterbury, using two-way video communication with multiple cameras and a shared whiteboard. The same technology was later used for the second public lecture by Marcus du Sautoy in March.

In April we launched another thematic programme, on Modelling Invasive Species, with a workshop at Hanmer Springs. This programme, which aims to design a mathematical and

statistics framework for exploring the spread and subsequent impact of invading organisms in New Zealand ecosystems, is involving positive interactions with the BioProtection CoRE, Landcare Research, AgResearch, the Auckland Regional Council, the Canterbury Regional Council, and Environment Southland, and has gained additional sponsorship from other sources, including the Miss E.L. Hellaby Indigenous Grassland Research Trust, and Landcare Research.

During the year we initiated three new thematic research programmes:

- Applications of Mathematics in the Nanosciences, led by Dr Shaun Hendy (Industrial Research Ltd and the MacDiarmid Institute)
- Algorithmics: New Directions and Applications, led by Professor Mike Atkinson (University of Otago) and Dr Charles Semple (University of Canterbury)
- Conformal Geometry and its Applications, led by Professor Gaven Martin (Massey University) and Associate Professor Rod Gover (University of Auckland).

In addition, we began to support ten further postgraduate research projects, being undertaken by Masters and PhD students at Auckland, Canterbury, Massey, Victoria and Waikato Universities, on a range of topics from pure and applied mathematics and statistics — see the section on Research by Postgraduate Students.

We appointed three overseas experts to short-term visiting Maclaurin Fellowships: Professors Edgar Knobloch (University of California, Berkeley), Jan Saxl (University of Cambridge), and Michael Eastwood (University of Adelaide), and we appointed Professor Eamonn O'Brien (University of Auckland) to a 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 will concentrate 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.

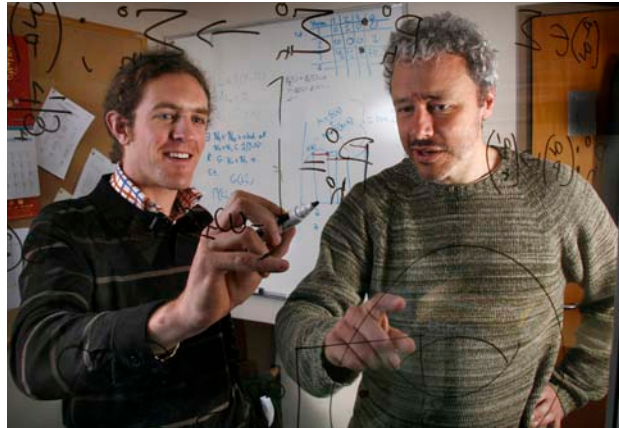
Also in 2007 we pursued several initiatives aimed at improving inclusion and retention of people from under-represented groups. A major initiative was a 3-day workshop for women researchers in the mathematical sciences in November. We also helped facilitate the Pangarau:AIM project, which is designed to trace mathematically achieving Maori students in Intermediate schools in Northland through their secondary careers in order to help gain an understanding of what makes them continue or discontinue in this subject, and a pilot study for a project aimed at attracting Samoan students into university education in New Zealand.

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. Among the most noteworthy in 2007 were the following:

- NZIMA Co-Director Vaughan Jones was awarded the 2007 Prix Mondial Nessim Habib in Geneva, for his achievements in mathematics;

- Professor Robert McLachlan (Massey University) won the Dahlquist Prize, for his outstanding contributions to geometric integration and composition methods for solving differential equations;
- Dr John Kernohan (a member of the NZIMA's Governing Board), won the Thomson Medal of the Royal Society of New Zealand, for "outstanding and inspirational leadership in the management of science";
- Professors James Sneyd (University of Auckland) and Rod Downey (Victoria University of Wellington) won James Cook Fellowships, in biological sciences and mathematical sciences respectively;
- The Optima Corporation (a spin-off company created by NZIMA principal David Ryan and his colleagues in the Engineering Science Department at the University of Auckland) won one of four Technology Commendations in 2007 from the Foundation for Research, Science and Technology (FRST).



Robert McLachlan (right) with NZIMA PhD student Dion O'Neale

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

- Sir Ian Axford and other members of the 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 amazing efficiency and initiative
- Julia Novak for filling in (so seamlessly) for as Research Manager while Margaret was on parental leave
- Professor Tom Barnes (DVC (Research)) and 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.

Finally, however, we have to report on the outcome of the Centres of Research Excellence (CoRE) Fund round.

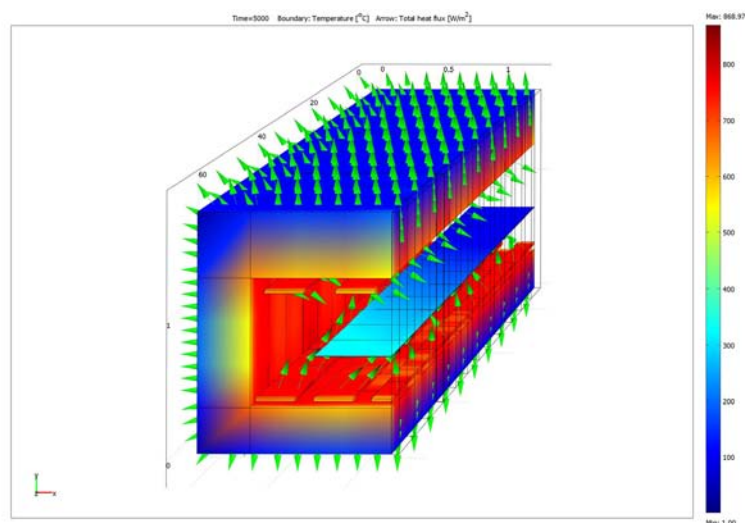
On the same day that Vaughan Jones was presented the Prix Mondial Nessim Habib at the University of Geneva, we were shocked to hear from the Tertiary Education Commission (TEC) that the NZIMA's proposal for a further six years of support from the had not succeeded. Instead, we have been granted a limited extension of CoRE funding

to mid-2011. Shortly afterwards we received official notification about this, containing feedback that was both difficult to comprehend and contradictory. Our case was a strong one (against all of the published criteria of the CoRE Fund), our referee reports were outstanding, and the support letters from New Zealand university departments and professional societies attested to the high value the NZIMA has brought to the mathematical sciences community in New Zealand and interactions with other disciplines and end-users. While acknowledging the NZIMA's research excellence, the strengths of its linkages, and the importance of mathematics as a fundamental discipline for New Zealand's future, the feedback indicated that the Selection Committee was unconvinced about how the NZIMA is "greater than the sum of its parts", how the NZIMA "provides synergy, cross-fertilisation and cohesion", and what value it is adding "over and above a simple increase in funding to existing research projects".

We lodged a very strong protest to the Prime Minister and the Ministers of Tertiary Education and of Research, Science & Technology about this decision (and some serious deficiencies in the way the selection process was carried out). Other bodies and individuals have also protested about the outcome, including the NZ Association of Mathematics Teachers, the International Council for Industrial & Applied Mathematics (ICIAM), members of our International Scientific Advisory Board, and the directors of other centres and institutes. Even the directors of other CoREs and members of the Academy and Council of the Royal Society of New Zealand have expressed alarm at the way in which research excellence appears to have been overlooked in favour of other issues of perceived importance in the selection process (yet not made explicit in the selection criteria) this time.

We have taken up these matters further with the TEC, in particular with respect to the question of future training opportunities for New Zealand students — with about half of our CoRE funding being spent each year on the support of students and postdoctoral fellows — and continuation of the many valuable activities that the NZIMA has been coordinating and supporting for New Zealand's benefit.

Marston Conder FNZMS FRSNZ FTICA
Vaughan Jones DCNZM FRS FRSNZ



Mathematical model of a steel furnace

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 2007 that show we are meeting these objectives. Further details can be found elsewhere in this report.

Research Excellence

- Professor Rod Downey (one of the NZIMA's principals and our first Maclaurin Fellow) has been elected a Fellow of the Association for Computing Machinery (FACM), for his contributions to computability and complexity theory.
- Professor Rod Downey also won a James Cook Research Fellowship from the Royal Society of New Zealand, in November 2007.
- NZIMA Co-Director Vaughan Jones was awarded the 2007 Prix Mondial Nessim Habif, in Geneva in June.
- Professor Robert McLachlan (one of the NZIMA's principal researchers) was awarded the Dahlquist Prize, at the SciCADE meeting in St Malo, in July 2007.
- The Optima Corporation, a spin-off company created by NZIMA principal David Ryan and his colleagues in the Engineering Science Department at the University of Auckland, won one of four Technology Commendations in 2007 from the Foundation for Research, Science and Technology (FRST).
- Professor David Ryan (member of our Executive Committee and co-director of our programme on transportation modelling) has been elected to a Fellowship of The Institute for Operations Research and the Management Sciences (INFORMS).
- Professor James Sneyd (one of our principal investigators) was awarded a 2-year James Cook Fellowship in biological sciences by the Royal Society of New Zealand, in early 2007.
- Researchers involved with the NZIMA have published a large number of articles in some of the world's top mathematics journals, including Annals of Pure and Applied Logic, Discrete and Computational Geometry, Journal of Algebra, Journal of the London Mathematical Society, Journal of Theoretical Biology, Mathematische Annalen, and Proceedings of the American Mathematical Society.

Knowledge Transfer

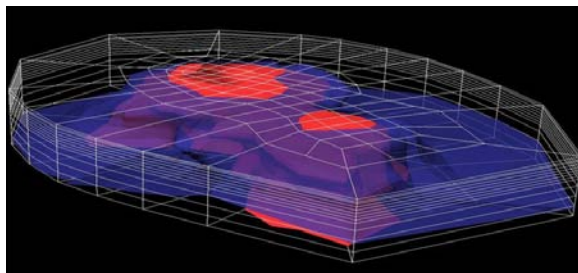
- Postgraduate students have been engaged in specific research projects by each of the NZIMA's programmes, with a total of 57 students having been directly engaged, while numerous others have been involved on programme based research
- A total of 16 postdoctoral fellows have been engaged on NZIMA programmes since 2002 (with some being supported by external sources such as the DFG, FRST and NIWA)
- The NZIMA organised or co-sponsored six conferences and workshops in 2007
- Each of the NZIMA's programmes has encouraged large numbers of students and professional mathematical scientists to take part in their conferences/workshops
- 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
- We have facilitated public lectures by high profile mathematicians including John Conway, Marcus du Sautoy, Ian Stewart and Vaughan Jones in 2007
- We are publishing a twice-yearly colourful bulletin, NZ-IMAgEs, to showcase a selection of mathematical activities across New Zealand, and make these accessible to a wider community
- Our web-based resource, MathsReach, 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



- 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 are undertaking research that has potential and actual benefits for New Zealand’s economy, society, and environment, such as the following:
 - The award-winning SIREN software, developed by the Optima Corporation (a spin-off company created by David Ryan and his colleagues) is being widely taken up, for example by services covering more than half the United Kingdom, and now in the US and Canadian markets.
 - Research on Hidden Markov Models by David Vere-Jones and his team is helping the NZ Earthquake Commission develop medium term probability forecasts
 - The mathematical and computer model of Wairakei geothermal field developed by Mike O’Sullivan and his team is now being used by Contact Energy in its \$1 billion-plus expansion plans
- 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



Three-dimensional computer model of Wairakei geothermal field

- We have encouraged the involvement of under-represented groups in research and postgraduate study in the mathematical sciences, and are celebrating their success
- 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: SUMMARY

The NZIMA has undertaken twelve principal thematic research programmes at various stages of development. Further details are given below. The first nine programmes were initiated between 2002 and 2005, the next two in 2006, and the others in 2007.

Logic and Computation: The central focus of this programme was research on the theories of computability and complexity, and the algorithmic study of randomness. Other areas of focus were finite and computable model theory and logics of programs, including complexity of decision problems and applications to specification and verification.

Programme director: Professor Rob Goldblatt (Victoria University of Wellington)

Status: This programme has been completed.

Modelling Cellular Function: This programme aimed to characterise, simulate and elucidate the mechanisms of cell function through the use of analytic and computational mathematical models. This involves integration of spatial-temporal scales and biological function in the hierarchy of cellular models, which will ultimately be required to link genomics with clinical medicine.

Programme director: Dr Nicolas Smith (Bioengineering, University of Auckland)

Status: This programme has been completed.

Numerical Methods for Evolutionary Problems: Evolutionary problems include ordinary differential equations, delay differential equations and differential-algebraic equations. Although traditional numerical methods for these problems are well established, more general methods are being developed that are capable of more efficient performance. Special numerical methods are being encompassed within the geometric integration framework for solving problems that evolve on manifolds.

Programme director: Professor John Butcher (Mathematics, University of Auckland)

Status: This programme has been completed.

Phylogenetic Genomics: This programme is bringing together leading experts to investigate the following topical problem: how can new types of genomic data best be used to infer evolutionary information?

Programme director: Professor Mike Steel (University of Canterbury)

Status: This programme has been completed.

Combinatorics and its Applications: This programme's major focus was on recent advances in combinatorics, with the aim of enhancing and developing linkages with the world's best combinatorial researchers, and applications to computational biology, complexity theory, theoretical computer science and abstract algebra.

Programme directors: Assoc. Prof. Paul Bonnington (Mathematics, University of Auckland) and Professor Geoff Whittle (Victoria University of Wellington)

Status: This programme has been completed.

Dynamical Systems and Numerical Analysis: This programme dealt with the theory and applications of dynamical systems and the numerical analysis of differential equations, with particular attention paid to interactions between the two areas.

Programme directors: Professor Robert McLachlan (Massey University), Dr Vivien Kirk (Mathematics, University of Auckland) and Dr Rua Murray (University of Waikato)

Status: This programme has been completed.

Geometry and its Interactions with Algebra and Analysis: This programme concentrated on recent developments in geometry and related areas of algebra and analysis, including geometric function theory, structure and classification of 3-manifolds, algorithmic and probabilistic group theory, and the "matrix group recognition project".

Programme directors: Professors Gaven Martin (Massey University) and Eamonn O'Brien (Mathematics, University of Auckland)

Status: This programme has been completed.

Mathematical Models for Optimizing Transportation Services: This programme's focus is on two broad areas of major importance: fleet and crew planning under uncertainty, and revenue management. Exploring the interface between these two areas is of particular interest. One major goal is to emphasise the interface between mathematical optimization and its applications in practical situations. This has been enhanced by engaging the support and participation of industrial partners.

Programme directors: Professor Andy Philpott, Assoc. Professor Matthias Ehrgott and Professor David Ryan (Engineering Science, University of Auckland)

Status: This programme is approaching completion.

Hidden Markov Models and Complex Systems: 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)

Status: This programme is approaching completion.

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 Gauld (Mathematics, University of Auckland), Dr Roger Fenn (University of Sussex) and Professor Vaughan Jones (University of Auckland and University of California, Berkeley)

Status: This programme is over half way through its intended duration.

Partial Differential Equations: Applications, Analysis and Inverse Problems:

This new 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, Professor Mike O’Sullivan and Professor Boris Pavlov (University of Auckland)

Status: This programme began in late 2006 and is continuing into 2008 and 2009.

Modelling Invasive Species and Weed Impact: The main aim of this new programme 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.

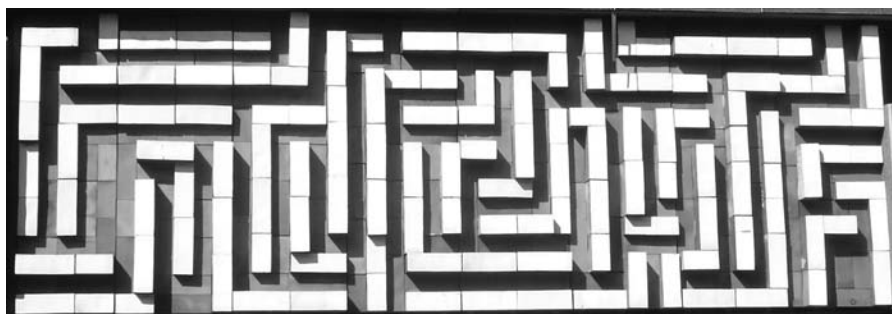
Programme directors: Dr Jennifer Brown, Dr Alex James and Professor David Wall (University of Canterbury)

Status: This programme began in late 2006 and is continuing into 2008 and 2009.

Applications of Mathematics in the Nanosciences: This programme has a focus on mathematical and computational methods for experimentation with and model-based prediction of nanoscale phenomena, and design and control of nanoscale systems.

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

Status: This programme began in 2007 and is continuing into 2008 and 2009.



THEMATIC PROGRAMMES: RESEARCH PROGRESS

The following seven 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

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.

The following programmes are at various stages of development:

Mathematical Models for Optimizing Transportation Services – Professor Andy Philpott, Assoc. Professor Matthias Ehrgott and Professor David Ryan (Engineering Science, University of Auckland) et al

The main focus of this programme is on transportation planning under uncertainty, optimizing the design of transportation systems, and pricing and revenue management, with additional points of focus on applications in practical situations, and engagement with industrial partners. The programme’s main period of activity was in 2005, and it is now approaching completion.

This year involved a number of overseas expert visitors:

- Professor Michael Trick (Carnegie-Mellon), as Hood Fellow and ORSNZ Visiting Lecturer, for 12 months;
- Professor Gerard Cachon (Wharton Business School), for 9 months, working on supply-chain games with Andy Philpott and PhD student Ziming Guan, and on revenue management games with Amir Joshan;
- Professor Garrett van Ryzin (Columbia Business School), funded by FRST, and working on revenue management optimization models with Andy Philpott;
- Professor Tava Olsen (Olin School of Business), funded by FRST;

- Professor Eddie Anderson (University of New South Wales), funded by FRST, and working on supply-function auction models with Andy Philpott.

In November, Andy Philpott organized a one-day Invited Symposium on Modelling Competition in Supply Chains, with four of the above visitors as main speakers, at the University of Auckland. This was sponsored by his FRST grant, and was attended by a small group of researchers and students, as well as industrial collaborators from Fonterra.

Five postgraduate research students (in the Engineering Science Department at the University of Auckland) are still engaged in the programme, as follows:

- Amir Joshan has been studying for a PhD on “Game-theory models for network revenue management”. He has been working closely with Gerard Cachon (Wharton), Andy Philpott and Golbon Zakeri on the use of a game theory model for network revenue management. He presented a paper at the INFORMS Annual meeting in Seattle in November 2007.
- Richard Lusby is undertaking a PhD on “Routing trains through stations”. He has developed optimization software for a new set-packing model to address this problem. The software is based on branch-and-bound and column generation, with a sophisticated use of the dual of the linear programming relaxation of the model to solve the problems of capacity assessment as well as disruption management in railway stations. He presented his work at the European Conference on Operations Research at Prague in July, and is preparing a paper on the subject. This is joint work with Jesper Larsen (Danish Technical University).
- Andrea Raith is close to completing a PhD on “Multicriteria transportation and routing problems”. She has written two papers on her work, the results which are currently being applied to the traffic assignment problem of transport planning (in joint work with Matthias Ehrgott and Dr Judith Wang (Civil and Environmental Engineering)). She presented her work at the European Conference on Operations Research at Prague in July, and the Annual Conference of the Operations Research Society of New Zealand in Auckland in December.
- Bassy Tam is undertaking a PhD on “Optimisation and simulation of airline crew schedules”. She has written a paper (with Matthias Ehrgott, David Ryan and Golbon Zakeri), which demonstrates the advantages of a bi-objective formulation of the problem as compared to a stochastic programming model. Her work on optimization methods to obtain unit crewed schedules has been published in the Proceedings of 42nd Annual Conference of the ORSNZ. Bassy has tested her methods on real data, with impressive results.
- Oliver Weide is close to completing a PhD on “Robust airline scheduling”. His paper “An iterative approach to robust and integrated aircraft routing and crew scheduling” (written with David Ryan and Matthias Ehrgott) has been accepted for publication in a special issue of Computers & Operations Research. He also presented his work at the European Conference on Operations Research at Prague in July, and at several other conferences in New Zealand, Italy and the US during the year.

A highlight of this programme is the degree of interaction with end-users of the research: Andy Philpott collaborates with the Energy Centre (comprising economists and engineers);

Bassy Tam and Oliver Weide have presented their work to Air New Zealand (which provided data for their projects), with very positive feedback; Richard Lusby presented his work to representatives of Deutsche Bahn (Germany), which provides data for the project and is very interested in the results; Andy Philpott and Ziming Guan have met regularly with staff of Fonterra to discuss data and results from their research project.

David Ryan (programme co-director) has been elected a Fellow of The Institute for Operations Research and the Management Sciences (INFORMS). Fellowship of INFORMS is “reserved for distinguished individuals who have demonstrated outstanding and exceptional accomplishments and experience in operations research and the management sciences”, and David is the first New Zealander to receive this honour.

The Optima Corporation, a spin-off company created by David Ryan and his colleagues, won one of four Technology Commendations in 2007 from the Foundation for Research, Science and Technology (FRST) in recognition of outstanding achievement in designing and applying cutting-edge technology. Optima’s commendation is for software systems that maximise use of staff and resources, developed by Dr Andrew Mason and his team. This latest award adds to the PriceWaterhouseCoopers Hi-Tech Innovation of the Year prize they won in 2006 for the SIREN system for ambulance deployment (which only two years after release is being taken up by services covering more than half the United Kingdom and is already pushing into the US and Canadian markets).

Hidden Markov Models – Emeritus Prof. David Vere-Jones (Victoria University of Wellington and Statistical Research Associates) et al

This programme commenced mid-2005, and it is now approaching completion.

Hidden Markov models (HMM) form a remarkably general and elastic framework for modelling systems through data that do not directly reflect the underlying dynamics. 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 are both 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.

David Harte and David Vere-Jones were invited to give lecture courses in Europe in 2007, in Prague and Milan, on aspects of point processes and stochastic models for earthquake occurrence. Both sets of lectures featured the use of hidden Markov models. David Harte’s work also featured in a presentation to the 5th International Statistical Seismology Workshop held in Erice, Sicily, in June.

Mark Bebbington is an active collaborator in the inter-institutional group, 'Volcanic Risk Solutions', and uses HMM techniques in that context. He is also organizing a session for the Bernoulli Society in France.

Dr Junko Murakami finished her postdoctoral fellowship in June 2007, and now has a temporary post at a university in Illinois, US. Her work focussed on the extension of Bayesian estimation procedures to hidden Markov models. She also assisted David Vere-Jones and others on a problem associated with Bath's Law in Seismology. Dr Pierre Ailliot, the other postdoctoral fellow (who finished in 2006), worked mainly with Peter Thompson and his colleagues John Sansom, Xiaogu Zheng, Jim Renwick and others at NIWA. Papers by both postdoctoral fellows are in the process of being published.

A third postdoctoral fellow, Dr Jan Bulla, funded by the German Research Foundation (DFG), joined the programme group in Wellington in 2007 to work with Peter Thomson and colleagues at NIWA, on hidden Markov and semi-Markov models for rainfall and climate change. Jan has continued his work on hidden semi-Markov models and other topics started while he was working on his PhD.



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 has been 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. It is expected that her visit will lead to longer-term collaboration between these groups. This project is part of a larger EQC project on time-varying earthquake hazard, which is funding the Evison Symposium in February 2008, and is assisting IGNS in developing a New Zealand Testing Centre for evaluating earthquake probability forecasts.

Three research students are involved:

- Shao-chuan Lv is now in the third year of his PhD, working with David Vere-Jones and David Harte in Wellington. He is preparing a paper for publication on extending the estimation procedures for hidden Markov models for point processes, to hidden Markov models for point processes with marks. He is using the hidden Markov model analysis to further explore the properties of New Zealand deep earthquakes.
- Wang Ting is now in the second year of her PhD, working with Dr Mark Bebbington at Massey (Palmerston North), with support from the Marsden Fund. Her work to date has had two main foci: one on exploring the response of a deep well (in Tangshan, China) to excitation from both near and distant earthquake waves, and the other on the development of robust procedures for inference on Hidden Markov models.

- Aaron Bryant is a summer student, working with Roger Littlejohn at AgResearch (Invermay) on “Fitting Hidden Markov models with feedback to deer feeding data”.
- In general, it is clear that the exposure afforded to the research in this programme through the NZIMA has greatly increased the international visibility of the work being done in New Zealand. Requests have been received for presentation notes from the two workshops associated with the programme. The best testimony, however, comes from the overseas graduates who have opted to come to New Zealand to work as postdoctoral fellows with the programme under their own funding.

Geometric Methods in the Topology of 3-Dimensional Manifolds – Prof. David Gauld (University of Auckland) et al

This programme commenced in January 2006, and is approaching completion.

The programme’s 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.

Roger Fenn has been working with Seiichi and Naoko Kamada (with computing assistance from Andrew Bartholomew) on long virtual and flat knots, and with Lou Kauffman et al on homfly polynomials of virtual links, and with Dale Rolfsen on braids over surfaces.

The programme’s postdoctoral fellow, Dr Richard Evans, completed his work on the “ending lamination conjecture” for hyperbolic 3-manifolds, and has taken up employment in the private sector.

Three postgraduate research students have been involved:

- Michael Brough, who undertook a research project on “Simple Seifert surfaces”, completed his Masters degree with First Class Honours at the University of Auckland.
- Stephen Budden is a PhD student at the University of Auckland (under the supervision of David Gauld), investigating the structure of “quandles”, especially their algebraic properties, and also their uses as knot invariants.
- Qing Zhang is studying for a PhD at Massey University’s Albany campus (under the supervision of Gaven Martin), working on the space of 2-generator discrete groups of hyperbolic isometries.

Partial Differential Equations: Applications, Analysis and Inverse Problems – Dr Colin Fox (University of Otago), Professors Mike O’Sullivan and Boris Pavlov (University of Auckland) et al

This new programme commenced in late 2006, with a short course of lectures given by Boris Pavlov at the University of Auckland.

It 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.

A summer workshop was held in January 2007 at Waitangi. The first two days included instructional lectures of an expository nature intended for students, given by Professors Jari Kaipio (of the Finnish Centre of Excellence in Inverse Problems Research) and Rowan Killip (a former student from Auckland now at UCLA) and others. For the rest of the week, excellent lectures were given by several experts in the field, including Boris Altshuler (Columbia), Jochen Brüning (Berlin), Stefan Finsterle (Lawrence Labs, Berkeley), Rostislav Grigorchuk (Texas A&M), Ernie Kalnins (Waikato), Pavel Kurasov (Stockholm) and Daniel Watzenig (Graz). A total of 43 people participated in the workshop, including ten New Zealand-based students, and five self-funded attendees from overseas.

Three projects were developed during the first part of the programme, each involving international experts who took part in the initial workshop.

The first of these projects is “Modelling and inverse problems for geothermal model calibration”. Several geothermal regions in New Zealand (such as Wairakei), water and steam from underground is tapped off for industrial uses. Sustainable management of these geothermal fields requires knowledge about the underground structure, which cannot be determined by direct measurement. The goal of this project is to develop sophisticated computer models of geothermal fields, using large systems of non-linear PDEs, with enhanced model calibration by solving the ‘inverse problem’ and applying novel methods of Bayesian inference (in order that predictions calculated with the model agree more closely with observations). The research initiated within the programme (by Mike O’Sullivan and others) is being trialed on a model of the Mokai geothermal field, developed for Contact Energy, Tuaropaki Trust and Mighty River Power.

The second project is “Sample-based inference for electrical impedance tomography”, being carried out by Colin Fox and others in collaboration with colleagues at the Los Alamos National Labs (LANL) in the US and the Technical University of Graz, in Austria. This project is using the canonical inverse problems of imaging electrical conductivity and permittivity, in order to develop new applications, new analytic and computational structures for the inverse problem, and stylised examples of imaging in porous media (as in hydrology). For example, a test-bed sampler is being constructed, to allow evaluation of a range of Bayesian methodologies (such as the delayed acceptance Metropolis-Hastings of Christen and Fox) to be evaluated in the context of electrical impedance imaging (EIT), conditioned on measured data.

The third project is “Mid-frequency sound transmission in lightweight timber framed structures”. This work (by Colin Fox and Boris Pavlov and others) is being conducted with industrial partners in the New Zealand and Australian timber building industries, including the New Zealand Pine Manufacturers Association, and Scion Research (formerly Forest Research) in Rotorua. The project will build on the successful models for low-frequency vibration and sound transmission of lightweight timber structures. The aim is to extend modelling to the mid-frequency range (>150 Hz) and also to complex flanking structures, in order to enable predictions that allow model validation and, ultimately, optimisation of the acoustic properties of timber-framed construction.

Two postdoctoral fellows are directly engaged in the programme:

- Dr Al Parker is working on new ergodic samplers for inverse problems in PDEs, with Colin Fox, Mike O’Sullivan and PhD student Tiangang Cui. He has

already made significant advances in understanding the numerical operation of a new ergodic sampler that does not require detailed balance.

- Dr Hyuck Chung is working (with support from a New Zealand Science & Technology Postdoctoral Fellowship) on the calculation of mid-frequency acoustic propagation in timber-framed constructions, focussing on modelling the effect that uncertainty in geometry and material properties have on the variational formulation that allows precise calculation at low frequencies.

Three postgraduate research students have been involved so far:

- Tiangang Cui is undertaking a PhD on Bayesian methods for inverse problems applied to geothermal model calibration, at the University of Auckland. He has made good progress on the difficult job of developing a principled formulation of modelling error for the case where ‘ground truth’ is not available, and has invented a beautiful new method for efficient use of approximations. He has also worked towards computer implementation of the delayed acceptance algorithm, generating new meshes for numerical modelling of the Mokai geothermal field.
- Christian Schwarzl, a Masters student from the Technical University of Graz, worked on sample-based inference for electrical impedance tomography, and has completed a thesis (under the co-supervision of Colin Fox) on “Robust parameter estimation in ECT using MCMC sampling” in December.
- Samuel Dillon, a Masters student at the University of Auckland, worked on the diagram techniques of Feynman and Arnold, fostered by the collaboration between his supervisor Boris Pavlov and visiting expert Pavel Kurasov, and has completed a thesis on “Multiple-Eigenvalues Perturbation and Associated Diagram techniques”.

A significant proportion of the activity within this programme involves researchers whose primary research focus lies outside mathematics — researchers in statistics, physics, architecture, engineering, and industry.

Colin Fox organised a symposium on Computational Inference in Inverse Problems at the First International Congress on Applied Inverse Problems, at Vancouver in June. Mike O’Sullivan co-organised the New Zealand Geothermal Workshop, at Auckland in November. Boris Pavlov co-organised a symposium on “New Trends in Spectral Analysis and PDE” within the First Joint Meeting of the American and New Zealand Mathematical Societies, held at Victoria University of Wellington in December. Boris Pavlov took part in (and was a scientific adviser for) a programme on Analysis on Graphs and its Applications run by the Isaac Newton Institute for Mathematical Sciences (UK) in the first half of 2007.

Modelling Invasive Species and Weed Impact – Dr Jennifer Brown, Dr Alex James and Professor David Wall (University of Canterbury) et al

This programme commenced in late 2006, with its main aim being 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.

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. For example, generous financial support has been provided by Landcare Research and the Miss E. L. Hellaby Indigenous Grassland Research Trust to support two PhD students, and two of the programme's expert visitors (Richard Law (York) and Lyman MacDonald (Wyoming) have been supported by the University of Canterbury's Erskine fund.

A successful 4-day meeting was held at Hanmer Springs in April 2007, with 49 attendees (including 7 students and 13 overseas participants). The main speakers were Alan Hastings (UC Davis), Richard Law (York), Mark Boyce (Alberta), Mark Lewis (Alberta), Lyman MacDonald (Wyoming), Tony Olsen (EPA), Susan Timmins (DoC) and Rob Phillips (Regional Council).



David Wall, Jennifer Brown and Alex James

Two postdoctoral fellows have been appointed so far:

- Dr Charles Tadjeran has worked on fractional diffusion models of invasive species;
- Dr Britta Basse is undertaking research on *Nasella* tussock models, and level set models of weed spread, in close collaboration with AgResearch.

Three postgraduate research students have been involved:

- Dawn Lemke is studying for a PhD at the University of Canterbury (with US funding), 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.

Applications of Mathematics in the Nanosciences – Dr Shaun Hendy (Industrial Research Ltd, and the MacDiarmid Institute, Victoria University of Wellington) et al

This programme commenced 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.

A small 2-day workshop on micro and nanofluidics was held in April at the University of Canterbury. This was attended by 23 people (including 6 students), from IRL/VUW, the Universities of Auckland, Lyon (France) and Canterbury, and Australo (a nanofluidics start-up company based in Dunedin).

The programme's main workshop, entitled "Mathematical and Computational Nanoscience (MCN-07)", took place in Wellington in December, jointly sponsored by the MacDiarmid Institute for Advanced Materials and Nanotechnology. This was attended by 45 people, including 15 students, and international participants from Australia, the US, Europe and Asia. The main theme of the workshop was multiscale modelling, with a particular focus on kinetic Monte Carlo methods, and another on the mathematical modelling of nanosystems. Notable were the student talks, which were of particularly high quality. A further highlight was the extensive interactions between researchers from the wide range of disciplines present, exemplified by a lively and constructive discussion between mathematicians in the Wollongong Nanomechanics group and the Massey University Theoretical Chemistry group, over a new geometric model for the structure of carbon nanotubes. Overall, the meeting was judged to be such a success by the New Zealand participants that it was decided to make it a regular event.

Overseas expert visitors in 2007 included Professors Tim Schulze (Tennessee), Art Voter (Los Alamos National Lab, US), Axel Voigt (Dresden), Peter Smereka (Michigan), Bjorn Engquist (Texas), Len Sander (Michigan), Mitchell Luskin (Minnesota), and Jim Hill (Wollongong). All of these experts took part in the workshop MCN-07 in December.

Three postdoctoral fellows have been involved, all working with Shaun Hendy at IRL, with financial support from FRST: Dr Brent Walker (developing new computational methods for calculating the optical properties of nanoparticles), Dr Nicola (developing modelling techniques to study the efficiency of electrocatalytic materials), and Dr Geoff Willmott (on the Navier slip boundary condition). All presented their results at MCN-07.

Six postgraduate research students are 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:

- Nathaniel Lund (VUW) worked on a Masters degree project with Shaun Hendy on deriving effective slip boundary conditions for surfaces with heterogeneous Navier slip boundary conditions, and this work has been well-received;
- Dmitri Schebarchov (VUW) is working with Shaun Hendy for a PhD on the melting of nanoparticles using molecular dynamics and mathematical modelling; he has developed

a new computer code for simulating the melting of nanoparticles on graphite substrates, and used this to find that palladium particles on graphite undergo a solid-solid phase transition from decahedral to face-centered cubic; an unexpected spin-off of his work has been the ability to simulate the interaction of carbon nanotubes (CNTs) with metal nanoparticles;

- Peter Zoontjens (VUW) completed a PhD on work with Shaun Hendy and Tim Schulze, in which he developed a new hybrid method for combining molecular dynamics and kinetic Monte Carlo methods for epitaxial growth;
- Jade Mackay (VUW) is working with Shaun Hendy for a PhD on developing a mathematical model of the growth of zinc oxide nanostructures by electrodeposition;
- David McCarthy (U Canterbury) is working with Simon Brown from NanoCluster Devices Ltd and Shaun Hendy on the coalescence of nanoparticles using the kinetic Monte Carlo method;
- Srikanth Dhondi (VUW) is working with Shaun Hendy and Gerald Pereira (CSIRO, in Melbourne) for a PhD on the flow of polymers in nanochannels.

MACLAURIN FELLOWS

Full year Maclaurin Fellows

Prof. Geoff Whittle (Victoria University of Wellington)

Geoff completed his 12-month tenure as a Maclaurin Fellow in mid-2007. The primary purpose of the research that he undertook was to make progress towards resolving two fundamental conjectures in matroid theory: Rota's Conjecture (on excluded minors for the class of representable matroids), and the Well-Quasi-Ordering Conjecture for representable matroids.

Rota's Conjecture dates from 1976 and has widely been regarded as the most important open problem in matroid theory. The Well-Quasi-Ordering Conjecture for matroids, if/when proven, will be a far-reaching generalisation of the corresponding theorem for graphs, proved recently by Robertson and Seymour.

For the last eight years, Geoff's primary research focus has been to work jointly with Professors Jim Geelen (University of Waterloo) and Bert Gerards (CWI Amsterdam) to develop the theory necessary to resolve these problems, by generalising the techniques of Robertson and Seymour to matroids. So far their work has met with steady success. Initially they were able to resolve both conjectures for classes of matroids of bounded branch width (an analogue of tree width). The next step was to prove that a $\text{GF}(q)$ -representable matroid with sufficiently large branch width contains the cycle matroid of a large grid graph as a minor.

At the beginning of the Maclaurin Fellowship, Geoff and his colleagues had made some progress towards developing a structure theorem of the class of $\text{GF}(q)$ -representable matroids that do not have the cycle matroid of a fixed clique or the dual of such a matroid

as a minor. This structure theorem was achieved. Their theorem generalises the analogous structure theorem of Robertson and Seymour, and moreover, gives an independent proof of Robertson and Seymour's (which was the workhorse of the Graph Minors project). It provides the technology that enables one to apply standard well-quasi-ordering techniques.

Unfortunately, before the same can be done for matroids, it is necessary to deal with another level of the hierarchy, and specifically, to develop a structure theorem for the class of $\text{GF}(q)$ -matroids with no fixed projective geometry $\text{PG}(n, q)$ as a minor. This was the other primary focus of Geoff's research during his Maclaurin Fellowship. While he cannot yet claim this result, he believes that a proof is in sight, and he is confident that it will be achieved before the end of 2008.



Geoff Whittle

Geoff has also been engaged in several other research projects, with complementary support from the Marsden Fund. With Dillon Mayhew (holder of a New Zealand Science & Technology Postdoctoral Fellowship, at VUW) and Gordon Royle (University of Western Australia), he has worked on the complementary problem of finding exact structural characterisations of certain classes of matroids (such as binary matroids with no $M(K_3, 3)$ -minor). With James Oxley (Louisiana) and Charles Semple (Canterbury) he has worked on somewhat technical problems associated with matroid connectivity, which are likely to be tools necessary to deal with connectivity aspects of Rota's Conjecture at some stage in the future. With Masters student Jeffrey Azzato he has worked on extending results for matroids of bounded branch width to infinite structure.

Prof. Graeme Wake (Massey University)

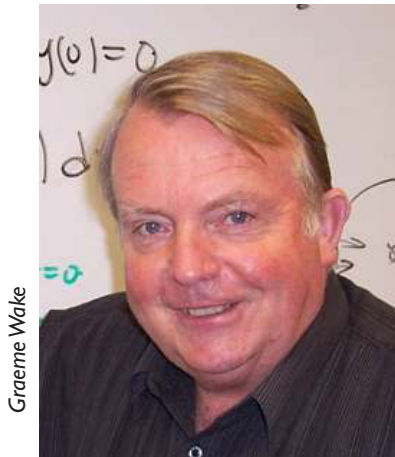
Graeme began his year as a Maclaurin Fellow in March 2007. The focus of his research has been the underlying theory and structure associated with functional differential equations where cause and effect are separated in space, size, and/or time, and so on. These exemplify a rich structure and usually are difficult to solve. They arise in a diverse range of applications and there is little generic theory.

The work is proceeding in two related streams in parallel: (a) non-local "spatially-structured" equations and spectral theory, and (b) delay and distributed-delay differential equations (DDDEs).

On the first of these, 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 presented these results in a contributed talk in the International Congress of Industrial & Applied Mathematics (ICIAM07) in Zurich in July.

He has also been investigating both point and distributed-delay ordinary differential equations, from an analytical and computational point of view, in association with Teeranush Suebcharoen, a PhD student on a one-year exchange from Bangkok (Thailand). In addition,



Graeme Wake

he was able to complete some work with colleagues at Oxford on gradient reaction-diffusion systems, and work with Busaya Pimpunchat (another PhD exchange student from Thailand) on the use of reaction-diffusion equations in modelling river pollution.

Graeme won a Fulbright Travel Grant to visit four universities in North America in November 2007, to give lectures and develop some joint research work; appropriately, one visit was to the Massachusetts Institute of Technology (where Richard Maclaurin was President in the early 1900s).

Graeme has been 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”, sponsored jointly by the NRGCD.

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.

Short-term Visiting Maclaurin Fellows

Prof. John Conway (Princeton University) is John von Neumann Distinguished Professor of Mathematics at Princeton University, and is one of the world’s most illustrious mathematicians. He visited New Zealand in January 2007, and spent two weeks at the University of Auckland, where he interacted with several researchers on a range of different topics (in group theory, number theory, game theory and topology), and gave a very well-attended and entertaining lecture on “The Game of Life”. This lecture proved so popular that we had to move to the largest lecture room available, to cater for well over 200 attendees.

Prof. Marcus du Sautoy (University of Oxford) was appointed as a Visiting Maclaurin Fellow for a brief period in March 2007. Professor du Sautoy is a talented mathematician best known not only for his work in group theory, but also for his ability in communicating and popularising mathematics. A frequent radio and TV commentator on aspects of mathematics and society, he is the author of the best-selling book on the Riemann hypothesis, *The Music of the Primes*, for which he won the Sartorius and



Marcus du Sautoy

Peano Awards. He visited the Universities of Auckland and Canterbury, giving lectures in each place. The public lecture he gave at Auckland on “The Music of the Primes” was advertised as the first in a series of joint activities with the Auckland Museum Institute (the Auckland branch of the Royal Society of New Zealand), was broadcast across the KAREN/BestGrid network, and was attended by over 350 people. He was interviewed by Kim Hill on National Radio.

New Maclaurin Fellowship appointments

Professor Eamonn O’Brien (University of Auckland) has been awarded a 12-month Maclaurin Fellowship beginning in the first half of 2008. Eamonn will undertake research in his specialist field of computational group theory - in which he is a world leader - 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.

We have selected the following as future Visiting Maclaurin Fellows:

Professor Michael Eastwood (Adelaide), January 2008 & August 2008. Eastwood is a leading international expert in the area of conformal geometry and has well over 100 publications covering differential geometry, complex analysis and Lie Group representation theory. These include a book and articles in *Annals of Mathematics* and *Notices of the American Mathematical Society* and elsewhere. His research standing was recognised in 1992 by the award of Australian Mathematical Society medal and more recently he was elected a Fellow of the Australian Academy of Science and also awarded an ARC Professorship. He has held many prestigious visiting fellowships including, for example, a Research Professorship at the Mathematical Sciences Research Institute, Berkeley in 2002

Professor Edgar Knobloch (UC Berkeley), July-September 2008. Edgar Knobloch is a world-leader in the areas of nonlinear dynamics and fluid dynamics, with around 240 refereed publications in these and related areas. He has visited New Zealand on two prior occasions, in 2002 as a UoA Foundation Distinguished Visitor and in 2004 as an invited participant in the NZIMA programme on Dynamical Systems and Numerical Analysis. During his proposed visit to New Zealand, he plans to work in two main areas: on an ongoing project on excitable systems and on a new project on global bifurcations in reversible systems.

Professor Jan Saxl (University of Cambridge), January 2008. He is a leading expert on finite groups: in particular, finite groups of Lie type, permutation groups and probabilistic group theory. He is a distinguished and prolific mathematician, with almost 100 refereed publications. Particular accomplishments include detailed characterisations of certain

classes of transitive and primitive permutation groups, and effective bounds on random generation of almost simple groups. He has held visiting positions at Princeton, MSRI, Caltech and the Hebrew University of Jerusalem.

RESEARCH BY CO-DIRECTORS AND OTHER PRINCIPAL INVESTIGATORS

Directors' Research

Professor Marston Conder has been continuing his research (supported also by the Marsden Fund) in combinatorial and computational group theory, with applications to the study of discrete objects with maximum symmetry. A particular highlight in 2007 was his work with Jozef Siran (Auckland, but now in the UK) and Tom Tucker in using group-theoretic techniques to prove the existence of infinitely many gaps in the genus spectrum of arc-transitive but chiral maps on orientable surfaces, and infinitely many gaps in the genus spectrum of regular maps on orientable surfaces with no multiple edges. These are being regarded as two of the three greatest breakthroughs in the study of regular maps in the last century. He obtained some new and interesting conditions for reflexibility of regular Cayley maps (in joint work with Jozef Siran (Auckland) and Young Soo Kwon (Postech, Korea), and on flippable pairs in comparative probability orderings (in joint work with Dominic Searles and Arkadii Slinko at Auckland). In addition in 2007, he served as President of the Academy of the Royal Society of New Zealand, and as a member of the New Zealand National Science Panel.



Marston Conder

Professor Vaughan Jones has been involved recently in two inter-related research projects. The first, with Dietmar Bisch (Vanderbilt University) is to define and analyse the free product of two planar algebras (and hence a notion of free composition of subfactors). The idea is to consider all planar diagrams with disjoint regions filled by diagrams from one or the other planar algebra. The technique of “middle patterns”, which they used in their analysis of the Fuss-Catalan algebras, can be used to give the fusion rules and hence in particular calculate the dimensions of the graded pieces of the free product. The result is remarkable — it can be expressed in terms of generating functions. The generating function for the free product is the free multiplicative convolution (in the sense of Voiculescu) of the individual generating functions. The other project is joint work with Alice Guionnet and Dima Shlyakhtenko, and is a general investigation of the relations between planar algebras and subfactors on the one hand, and free probability and random matrices on the other — a specific instance of which is the work with Bisch mentioned above.



Vaughan Jones

The results are preliminary at the moment, but already impressive, having produced a planar and fully functorial proof of the existence of a subfactor ‘coordinatising’ a planar algebra. This result was proved by Popa and others and is a cornerstone of subfactors and planar algebra. But other proofs always involved some arbitrary external input. In another direction the planar language has been proving useful in manipulating certain traces coming from Gaussian integrals with potentials over large dimensional matrix spaces. In the limit as the size of the matrices tends to infinity the t’Hooft expansion sees only planar diagrams so all the expected values can be expressed as sums of labelled planar tangles. This work looks very promising indeed.

Research by other Principal Investigators

Much of the research by our principal investigators is already summarised in the earlier progress reports on NZIMA thematic programmes. In addition, there are several strands of research carried out by the NZIMA’s by our principal investigators that are complementary to those programmes, supported by sources other than the CoRE Fund. Here is a brief selection of these:

Professor John Butcher (University of Auckland) and his research group have continued with their research on the development and implementation of general linear methods for the solution of stiff and non-stiff differential equation systems. Error estimation for both variable step and variable order algorithms are now known (joint work with Helmut Podhaisky, Halle University) and these are extremely accurate and efficient for nonstiff problems.

In the case of stiff problems, although the technique is asymptotically correct, it can give misleading behaviour for moderate stepsizes. Preliminary investigations on how this can be corrected are on-going. In collaboration with Adrian Hill (Bath University) it has been shown how non-linear stability can be characterized for linear multistep methods. In collaboration with Laura Hewitt (Bath University) a direct proof has been found for the non-existence of symplectic general linear methods, unless they reduce to Runge-Kutta methods. In spite of this result, G-symplectic methods are available, and these give results remarkably similar to what would be found for symplectic methods. The second edition, greatly revised and extended, of Butcher’s 2003 book, “Numerical Methods for Ordinary Differential Equations”, is due for publication in March 2008.

Professor Mike Steel’s (University of Canterbury) book, “Reconstructing Evolution: New Mathematical and Computational Advances”, (edited by Steel and Oliver Gascuel) was published in June 2007. This book arose from the conference, “Mathematics of Evolution and Phylogeny”, held at the Institut Henri Poincaré, Paris in 2005, that attracted 900 people, and led to the three involved societies subsequently voting to hold this meeting outside North America on a semi-regular basis.

Mike Steel’s programme on Phylogenetics at The Isaac Newton Institute for Mathematical Sciences ran from September to December 2007 and had more than 100 people taking part. The IEEE/ACM Journal on Computational Biology and Bioinformatics devoted a special issue to 12 proceedings papers arising from the programme. A popular report will appear shortly in the Millenium Mathematics Project Plus magazine (<http://plus.>

maths.org/). A new initiative for Mike Steel is a joint project with Oxford University to develop a theory for reconstructing detailed human pedigrees from whole genomes, funded mainly by the UK's Engineering and Physical Sciences Research Council.

Professor James Sneyd (University of Auckland) has continued his studies of the dynamics of calcium in a variety of cell types, with particular focus on their role in airway smooth muscle contraction, the secretion of saliva, and the control of the heart beat. With Vivien Kirk he has obtained a Marsden Grant to study the role of canards in calcium oscillations. In 2007 he completed the second edition of his research textbook, "Mathematical Physiology", co-authored with James Keener, which is expected to appear in June 2008. In 2007 he also participated in a major multi-investigator grant application to the NIH in the United States which was successful.

For the next year he will continue to hold a James Cook Fellowship, during which time he will work on multi-level studies of asthma and of saliva secretion. He is also developing new methods of constructing hybrid deterministic/stochastic models of calcium micro-domains, and how to connect them to whole-cell models.

RESEARCH BY POSTGRADUATE STUDENTS

In addition, the following postgraduate research student projects were supported by the NZIMA in 2007 (based on the merit of the student and the value of their project):

- Robin Averill (Victoria University of Wellington), PhD in mathematics education
- Tiangang Cui (University of Auckland), PhD on geothermal model calibration
- Blaise Drinkwater (Victoria University of Wellington), Masters project on randomness
- Jonathan Crook (Victoria University of Wellington), PhD on modelling sea-ice
- Michael Hayward (University of Canterbury), Masters project on population estimation
- Maarten Jordens (Massey University), PhD on distortion functionals and variations
- Joshua Koh (University of Auckland), Masters project on flow in petroleum reservoirs
- Xinshan Li (University of Auckland), PhD on modelling childbirth
- 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
- Qizhi Zhou (University of Waikato), PhD in number theory.

VISITING EXPERTS

- Professor Boris Altshuler (Columbia University)
- Professor Eddie Anderson (University of New South Wales)
- Professor Mark Boyce (University of Alberta)
- Professor Jochen Brüning (University of Berlin)
- Professor Gerard Cachon (Wharton Business School)
- Professor John Conway (Princeton University)
- Professor Tommy Dreyfus (Tel Aviv University)
- Professor Marcus du Sautoy (University of Oxford)
- Professor Bjorn Engquist (The University of Texas at Austin)
- Dr Stefan Finsterle (Lawrence Labs, Berkeley)
- Professor Rostislav Grigorchuk (Texas A&M University College)
- Professor Alan Hastings (UC Davis)
- Professor Jim Hill (University of Wollongong)
- Professor Jari Kaipio (Finnish Centre of Excellence in Inverse Problems Research)
- Associate Professor Rowan Killip (UCLA)
- Dr Ville Kolehmainen (University of Kuopio)
- Associate Professor Pavel Kurasov (Lund Institute of Technology)
- Professor Richard Law (University of York)
- Professor Mark Lewis (University of Alberta)
- Professor Mitchell Luskin (University of Minnesota)
- Professor Lyman MacDonald (University of Wyoming)
- Professor Tava Olsen (Olin School of Business at Washington University in St. Louis)
- Dr Tony Olsen (US Environmental Protection Agency)
- Dr Hinke Osinga (University of Bristol)
- Professor Len Sander (University of Michigan)
- Professor Tim Schulze (University of Tennessee)
- Professor Peter Smereka (University of Michigan)
- Professor Ian Stewart (University of Warwick)
- Professor Michael Trick (Carnegie-Mellon University)
- Professor Garrett van Ryzin (Columbia Business School)
- Professor Axel Voigt (Dresden University of Technology)
- Professor Art Voter (Los Alamos National Lab, US)
- Dr Daniel Watzenig (Graz University of Technology)

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 2007:

- A 3-day workshop for women researchers in the mathematical sciences was held at the Vaughan Park Retreat and Conference Centre at Long Bay, Auckland, in November. This meeting drew together 35 participants (including 18 PhD and 2 Masters students, many early career researchers, and a small number of more senior women), from university departments of mathematics, statistics, computer science and engineering science (at Otago, Massey, Canterbury and Auckland), and from NIWA. The emphasis of the workshop was on providing information helpful to smooth progression into and through a career in research, and to provide opportunities for mentoring and networking. Special sessions were devoted to the PhD years, progression and promotion, work-life balance, mentoring, and cultural diversity. Participants generally enjoyed and gained a lot from the workshop, and reported that they left the workshop with renewed enthusiasm and focus on their careers, and with new skills and knowledge about how to plan their careers. They were also highly appreciative of the opportunity to make connections with other women working in similar areas. The workshop was organised by Vivien Kirk (Auckland) and Alex James (Canterbury) on behalf of the NZIMA, with additional financial support coming from the Kate Edger Educational Charitable Trust.
- The first New Zealand Mathematics and Statistics Postgraduate (NZMASP) Conference was held in Queenstown for two days in November 2007. Nearly forty postgraduate students from six New Zealand Universities presented their research, on topics ranging from abstract algebra to physiological modelling, from Bayesian statistics to mathematics education. This conference provided a forum to develop conference presenting skills for those beginning their research careers, as well as strengthening ties between postgraduate students across the Universities. Attendees gratefully acknowledged the sponsorship from the NZIMA as well as the University of Canterbury and Hoare Research Software (HRS).
- The NZIMA was very pleased to help sponsor the first joint meeting of the American and New Zealand Mathematical Societies, which was held in Wellington in December. With over 300 participants, this was one of the largest mathematical events ever held in New Zealand. It attracted a large number of participants from Europe, Asia and Australia. Half of the eight invited plenary lectures were given by principal investigators of the NZIMA (Marston Conder, Rod Downey, Gaven Martin and Matt Visser), with the other four given by US mathematicians. The meeting was highly successful and has sparked several new collaborations.
- In addition, the co-directors of the NZIMA's programme on Dynamical Systems and Numerical Analysis sponsored a special session on dynamical systems and ergodic theory within the above AMS-NZMS meeting.

Public Events

- John Conway FRS (Visiting Maclaurin Fellow), on “The Game of Life”, at the University of Auckland on 25th January;
- Marcus du Sautoy (Visiting Maclaurin Fellow), on “The Music of the Primes”, in Christchurch on 15th February, and in Auckland on 15th March;
- Vaughan Jones (NZIMA Co-Director), on “Flatland – a great place to do algebra”, at Victoria University of Wellington on 16th March, and at the University of Auckland on 6th December;
- Charles Leedham-Green (University of London), on “Newton’s Principia”, at the Auckland Museum, on 4th April;
- Ian Stewart (University of Warwick), Seelye Fellow, on “All the World’s a Network”, at the University of Auckland on 4th October;
- Ian Stewart (University of Warwick), Seelye Fellow, on “The Pattern of Tiny Feet” (the 2007 Archey Lecture), at the Auckland Museum; on 9th October.

AWARDS AND HONOURS

The following is a selection of awards and honours won by NZIMA people in 2007:

- NZIMA Co-Director Vaughan Jones was awarded the 2007 Prix Mondial Nessim Habif by the University of Geneva, for his achievements in mathematics. This is an annual prize awarded to prominent researchers from all disciplines. In 1990 Vaughan won a Fields Medal (widely regarded as equivalent to a Nobel Prize in Mathematics), and until last year was the only recipient of this award from the southern hemisphere. He was also the first winner of New Zealand’s Rutherford Medal in 1991. He was presented with the Prix Mondial Nessim Habif at a special ceremony at the University of Geneva in June.
- Professor Cheryl Praeger, a member of our International Scientific Advisory Board, won one of 20 Federation Fellowships by the Australian Research Council this year. These fellowships, which are very generously funded, are highly prestigious awards designed to develop and retain highly skilled researchers within Australia and attract such researchers from overseas.
- Dr John Kernohan, a member of the NZIMA’s Governing Board, won the Thomson Medal of the Royal Society of New Zealand, for “outstanding and inspirational leadership in the management of science”. John was the founding



Cheryl Praeger

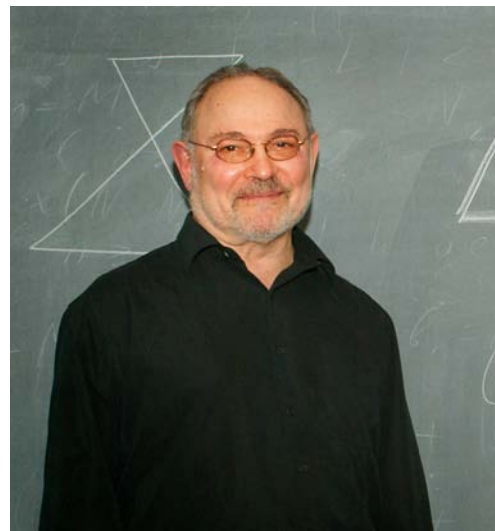
CEO of UniServices, the commercial research and knowledge transfer company for the University of Auckland, and is credited with building up its activities to the point where it now accounts for a remarkable ten percent of the University's total revenue, a higher percentage than almost any other university in the world.

- Professor James Sneyd (University of Auckland) was awarded a 2-year James Cook Fellowship in biological sciences by the Royal Society of New Zealand. These fellowships are awarded to “forward thinking” researchers who will make a significant contribution to New Zealand's knowledge base.
- Professor Mike Saunders, of Stanford University and a member of the NZIMA's International Scientific Advisory Board, was this year elected as an Honorary Fellow of the Royal Society of New Zealand. Mike is a world expert in the development of mathematical optimisation software for solving decision problems in large interconnected systems.



James Sneyd

- Professor Ernie Kalnins (from the University of Waikato, a member of the programme committee for the NZIMA's thematic programme on Conformal Geometry) won the New Zealand Mathematical Society's 2007 Research Award, for his wide-ranging, prolific and significant contributions to research on symmetries of partial differential equations, separable coordinates and superintegrable systems.
- Professor Hyman Bass (one of our visiting Maclaurin Fellows in 2006) won a U.S. National Medal of Science, presented by the U.S. President at a special ceremony in July 2007. He was awarded this medal for his work in establishing the branch of mathematics known as algebraic K-theory, and was one of only eight awardees (across all the sciences) and the only one in mathematics for the year. These medals are intended to “honour pioneers in scientific research who enhance understanding of the world and create innovations that give the United States an economic edge in the global market”.



Hyman Bass

- Professor Rod Downey (one of the NZIMA's principals and our first Maclaurin Fellow) has been elected a Fellow of the Association for Computing Machinery (FACM), for his contributions to computability and complexity theory. ACM Fellows, from some of the world's leading universities, industries, and research labs, are elected for the innovations they have created in a range of computing disciplines that affect theory and practice, education and entertainment, industry

and commerce. Rod is only the second such Fellow in New Zealand, and the only other 2007 ACM Fellows from outside of North America are from Oxford University, the University of Edinburgh, the École Polytechnique Fédérale de Lausanne (EPFL) in Switzerland, and the University of Madeira.

- Professor Rod Downey also won a James Cook Research Fellowship from the Royal Society of New Zealand, in November 2007. These fellowships (widely regarded as New Zealand's most prestigious science and technology awards) are given to "forward thinking" researchers who will make a significant contribution to New Zealand's knowledge base, allowing them to concentrate on their chosen research close to full-time for two years. Rod is the fourth of our principal researchers to win one out of 38 awardees in total since 1997 (the others being Peter Hunter (1999), Gaven Martin (2001), and James Sneyd (2007)).



Rod Downey

- Professor Robert McLachlan (one of the NZIMA's principal researchers) was awarded the Dahlquist Prize, at the SciCADE meeting in St Malo, in July 2007, for his outstanding contributions to geometric integration and composition methods for solving differential equations. This is the principal world prize in numerical differential equations, and was widely reported in the New Zealand popular media and in the world scientific media. Robert was director of our programme in Dynamical Systems and Numerical Analysis, and was our Maclaurin Fellow in 2005/06.



- The Optima Corporation, a spin-off company created by NZIMA principal David Ryan and his colleagues in the Engineering Science Department at the University of Auckland, won one of four Technology Commendations in 2007 from the Foundation for Research, Science and Technology (FRST), in recognition of outstanding achievement in designing and applying cutting-edge technology. Optima's commendation is for software systems that maximise use of staff and resources, developed by Andrew Mason and his team. This latest award adds to the PriceWaterhouseCoopers Hi-Tech Innovation of the Year prize they won in 2006 for the SIREN system for ambulance deployment (which only two years after release is being taken up by services covering more than half the United Kingdom and is already pushing into the US and Canadian markets).
- Professor David Ryan (member of our Executive Committee and co-director of our programme on transportation modelling) has been elected to a Fellowship of The Institute for Operations Research and the Management Sciences (INFORMS). Fellowship of INFORMS is "reserved for distinguished individuals who have demonstrated outstanding and exceptional accomplishments and experience in

operations research and the management sciences”, and David is the first New Zealander to receive this honour.

- Researchers involved with the NZIMA have published a large number of articles in some of the world’s top mathematics journals, including Annals of Pure and Applied Logic, Discrete and Computational Geometry, Journal of Algebra, Journal of the London Mathematical Society, Journal of Theoretical Biology, Mathematische Annalen, and Proceedings of the American Mathematical Society.

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 be 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.

The NZIMA is a member of the Atlantic Association for Research in the Mathematical Sciences (AARMS), which helps coordinate research activities in the four eastern-most provinces of Canada. We will be looking at ways in which we can facilitate participation by students in each other’s summer schools and workshops, and encourage other joint activity.

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

The NZIMA's Governing Board is developing its role in terms of formulating strategy, as well as continuing its oversight of the operations and finances of the NZIMA. This board met once in 2007, in May. Key ongoing challenges for the board are to formulate strategies for the NZIMA to build its activities, funding, profile and outreach, with the additional challenge (currently) of dealing with the outcome of the 2006/07 CoRE selection round.

MANAGEMENT

Our Executive Committee (Marston Conder, Vaughan Jones, Rod Downey, David Ryan and Graham Weir) transacts its business by telephone and electronic mail.

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 (Margaret Woolgrove) 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, NZIMAgEs and items for our schools' website, MathsReach.

INTERNATIONAL SCIENTIFIC ADVISORY BOARD

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

The Advisory Board is chaired by Vaughan Jones and transacts its business by telephone and electronic mail.

TRAINING OBJECTIVES

Each NZIMA thematic programme is expected to run at least one workshop in which postgraduate students and postdoctoral researchers are encouraged to participate.

Maclaurin Fellows and other visiting experts are encouraged to interact with postgraduate students and postdoctoral researchers.

Each NZIMA thematic programme normally appoints at least one postdoctoral fellow (for two years FTE) and at least two postgraduate research students (for up to three years).

Scholarship support is also provided to a number of other postgraduate research students on a merit basis, including students engaged on projects in industrial mathematics.

DEVELOPMENT OBJECTIVES

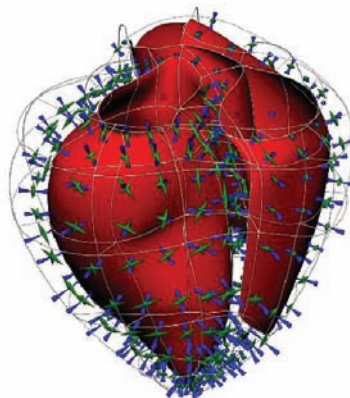
The NZIMA is pursuing strategies (developed in consultation with the Governing Board and Advisory Board) for building up its activities, funding and profile.

The two Co-Directors are interacting with executives of other CoREs in New Zealand and other mathematical sciences institutes overseas to help develop future strategies and explore opportunities for closer interaction.

The possibilities of improved networking, coordination of activities, training (including summer schools), infrastructural assistance, sharing of expertise and pooling of resources are being explored through the newly formed Pacific Rim Mathematical Association ('PRIMA'). The NZIMA is a founding member of this association, and Marston Conder is a member of its Liaison Committee.

Signage for the NZIMA has been installed at its home base at the University of Auckland and is also made available for researchers affiliated with the NZIMA in other parts of New Zealand.

A high priority recently has been one of outreach, through the NZIMA's new IMAgEs glossy bulletin (of news, events and articles about mathematical activities) and MathsReach initiative (to show school teachers, students and their parents what lies beyond the school curriculum in the mathematical sciences).



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

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 2007 year

Income	Actual	Budget	Variance
CoRE Funding	\$ 2,038,889	\$ 1,631,111	\$ 407,778
Host/Partner Support	57,491	0	57,491
Total Income	\$ 2,096,380	\$ 1,631,111	\$ 465,269
Expenditure	Actual	Budget	Variance
<i>Salaries</i>			
Director & Principal Investigators	\$ 88,035	\$ 81,000	\$ (7,035)
Associate Investigators	177,088	197,600	20,512
Postdoctoral Fellows	139,721	216,000	76,279
Research/ Technical Assistants	0	0	0
Others	57,827	24,300	(33,527)
<i>Total Salaries (a)</i>	<i>\$ 462,671</i>	<i>\$ 518,900</i>	<i>\$ 56,229</i>
<i>Other Costs</i>			
Project Costs	\$ 292,499	\$ 113,400	\$ (179,099)
Travel	94,256	108,000	13,744
Postgraduate Student Support	421,367	285,311	(136,056)
Indirect Costs: Overheads	418,458	518,900	100,442
Equipment depreciation	0	0	0
Rental - equipment	1,939	65,000	63,061
Subcontractors	0	0	0
Extraordinary expenditure	0	21,600	21,600
<i>Total Other Costs (b)</i>	<i>\$ 1,228,519</i>	<i>\$ 1,112,211</i>	<i>\$ (116,308)</i>
Total Expenditure	\$ 1,691,190	\$ 1,631,111	\$ (60,079)

Statement of Financial Position as at 31 December 2007

	Previous total	Current year	Nett total
Funds committed but not yet spent	\$ 1,386,995	\$ 405,190	\$ 1,792,185
Represented by			
Thematic programmes 2006/07/08			\$ 1,221,617
Maclaurin fellowships 2007/08			19,000
Postgraduate scholarships 2006/07/08			551,568
Total commitments going forward			\$ 1,792,185

DETAILS OF PUBLICATIONS AND OTHER RESEARCH OUTPUTS

The following is a selection of publications in 2007 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

Albert, M. H.: On the length of the longest subsequence avoiding an arbitrary pattern in a random permutation. *Random Structures Algorithms* 31 (2007), no. 2, 227-238.

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An, Jianbei: Uno's invariant conjecture for Chevalley groups $G_2(q)$ in nondefining characteristics. *J. Algebra* 313 (2007), no. 2, 429-454.

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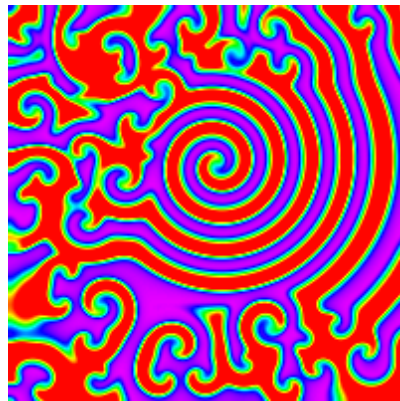
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