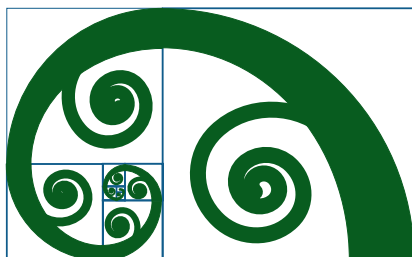


# **New Zealand Institute of Mathematics and its Applications (NZIMA)**

## **Annual Report 2010**



New Zealand Institute of  
Mathematics & its Applications



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## OVERVIEW FROM CHAIR OF THE NZIMA BOARD

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

During the past year we have worked to organise how we think about the work of the Institute (and of mathematicians, statisticians and computer scientists more generally) in ways that fit recent thinking about long and short run added value. This should place the NZIMA on a better footing to compete with other science institutions for an appropriate share of the resources available overall for science in New Zealand. We have been slower at getting these ideas across to those whose awareness affects the



Len Cook

place of NZIMA, but believe we are well placed to do this intensively in the early part of 2011.

The leadership groups convened by the Directors in each location have unearthed a rich body of information about the outcomes of a wide range of projects undertaken, and more particularly, these put us in a good position to match the achievements with the benefits of their impact.

In New Zealand the establishment of CoREs is one of the few ways that government has sought to deliberately build up a critical mass of experts in any field, so that the scope of what is done can significantly change. The national benefits of international collaboration and continuing engagement with those in overseas centres are of more value when they are sustained, and can draw in a wide range of colleagues. The Director and the Board have been working to have the value of this recognised.

We do not know when another CoRE funding round will take place. Finding a well reasoned justification for seeking transitional support from those organisations best placed for this will be contingent on how well the long term value of the Institute can be demonstrated, and the willingness of those bodies to avoid the costs of winding down then rebuilding NZIMA in another guise at some later time. The Directors are developing a robust, long-term model which has been presented to associates of the Institute, receiving generally strong support in the face of some reservations.

Getting involved in this work has convinced me more than ever of how important it is for New Zealand's future, and for the choices that we want to have about how we generate wealth, that we invest wisely and bolster the mathematical and statistical capability of this country. Moreover, given that the organisation of science is again subject to re-think and re-organisation, it is important that we recognise the potential wider applicability of the research produced by this institute, and recognise and value the results of its achievements.

The NZIMA continues to set the highest standards for the CoREs in terms of the quality and range of publications, and this year's results would have been worthy of a gold medal if we had been a sports team.

For the NZIMA board, I would like to express our appreciation of the leadership of NZIMA by the Co-Directors, Professor Marston Conder and Professor Sir Vaughan Jones, and the support of the Research Manager, Margaret Woolgrove. Their leadership this year has given renewed vigour to demonstrating the value of the work of the Institute and its investigators. This has given us genuine hope that we can effectively assert sound reasons for the continuing existence in some form of a CoRE for the mathematical and computational sciences in New Zealand, and raised the possibility of support in the meantime to continue at a reduced level after the 2010/2011 year.

**Len Cook**

## REPORT FROM DIRECTORS AND EXECUTIVE COMMITTEE

This annual report gives yet another indication of the golden age of mathematics that New Zealand is currently experiencing.

Two particular achievements in 2010 stand out. At the 51st International Mathematical Olympiad held in July, New Zealand's team posted a record performance, with every team member winning a medal – and on one of the six questions, all six team members achieved a perfect score. A month later, at the International Congress of Mathematicians held in August, invited lectures were given by not one, not two, but three New Zealand based researchers (Bill Barton, Gaven Martin and André Nies).

As we reported last year, some recent statistics from the Web of Science show that since the 1990s, the numbers of publications in mathematical journals by New Zealand based authors has almost tripled, lifting the rank of mathematics among all disciplines in New Zealand from 22nd place in 1990–94 to 11th place in 2005–09. We believe this improvement, which is ongoing, is due in no small part to the role played by the NZIMA and its founding partner, the NZMRI (Inc.).

An analysis of publications by NZ Centres of Research Excellence (CoREs) over the years 2004, 2006 and 2008 has been carried out by Warren Smart at the Ministry of Education, based on information from CoRE annual reports. This analysis is very positive for the NZIMA. It shows, for example, that over those three years, the NZIMA reported 269 publications, with 70% of them in journals rated A or A\* under the new Australian ERA evaluation system. The other CoREs together reported 1385 publications, with 51% in A or A\* journals. In fact the NZIMA reported 16% of the combined total of reported publications and close to 22% of those in A or A\* journals – on a budget of about 5% of the total CoRE Fund.

The year 2010 got off to an excellent start with a summer meeting on Groups, Representations and Number Theory, organised by Ben Martin and Eamonn O'Brien. Some of our thematic programmes have reached their official end, but the benefits of these programmes continue, especially because of the connections they have set up, and the stimulus they have provided for future activity. We describe in detail much of the progress of our four current programmes in this report. Our programme on Energy, Wind and Water is making great progress, and is developing strong

interactions with Contact Energy Ltd and the Energy Development Corporation. Our programme on Senior Secondary and Undergraduate Mathematical Science in New Zealand is developing an action plan aimed at ensuring the provision of a sufficient flow of competent graduates to meet the needs of all sectors of society that require mathematical knowledge and abilities beyond Year 11.

Our new Governing Board met twice in the early part of 2010, and has given us some valuable strategic advice on the future of the NZIMA. During the period July to mid-September, Marston Conder and James Sneyd visited mathematical sciences departments in New Zealand universities to discuss possible new models for the NZIMA, and the way forward, with emphasis on balancing the complementary aims of building further research excellence, developing capability, and achieving beneficial outcomes in economic, social and/or environmental terms.

On a sad note, we lost a member of our International Scientific Advisory Board, Professor Jerrold Marsden (from the California Institute of Technology), who died unexpectedly in September. Jerry was one of the world's best applied mathematicians, well known for his ability to bring together different disciplines, connecting mathematical theory with physical models and practical applications.

Finally, as usual we would like to thank all those who have been involved positively in NZIMA's operations this year. We'd especially like to thank Len Cook (chair of our new Governing Board), directors of our current programmes and summer workshops, Margaret Woolgrove (Research Manager), Judy Paterson (who is helping with outreach to schools), Jenny Rankine for her assistance in producing NZ-IMAgEs, and Neil Morrison, Rob Carter, Yvette Wharton and John Glass for their work with Margaret on our MathsReach resource. In addition, we'd like to thank heads of departments and leaders of professional societies in the mathematical sciences in New Zealand for their continued and valuable support of the NZIMA.

**Marston Conder FNZMS FRSNZ FTICA**

**Vaughan Jones KNZM FRS FRSNZ**

## **PROGRESS WITH RESPECT TO CoRE FUND OBJECTIVES**

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

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

Below are some of the highlights of the NZIMA's activities and achievements in 2010 that show we are meeting these objectives. Further details can be found elsewhere in this report.

### **Research Excellence**

Our programmes are bringing together some of the world's best researchers in the relevant theme area, providing an excellent basis for stimulating top quality research and training students in New Zealand.

Significant advances in knowledge and applications are resulting from NZIMA activities - see the sections on Thematic Research Programmes, Maclaurin Fellowships and Postgraduate Research Projects.

Researchers involved with the NZIMA published a large number of articles in some of the world's top mathematics journals in 2010, including Archive for Rational Mechanics and Analysis, Comptes Rendus Mathématique - Académie des Sciences (Paris), Journal of Algebra, Journal of Combinatorial Theory, Journal of the European Mathematical Society, Journal of Mathematical Biology, SIAM Journal on Applied Mathematics, and Transactions of the American Mathematical Society.

NZIMA researchers have continued to win numerous honours and awards in 2010, including the following:

- Aitken Prize of the New Zealand Mathematical Society (Rachael Tappenden)
- Fellowship of Royal Society of New Zealand (André Nies)
- Jones Medal of Royal Society of New Zealand (John Butcher)



- New Zealand Mathematical Society Annual Research Award (Charles Semple)
- Research Medal of New Zealand Association of Scientists (Shaun Hendy)
- Shoenfield Prize of Association of Symbolic Logic (Rod Downey and André Nies)



Charles Semple, NZMS Annual Research Awardee

Of particular note is the fact that three NZ-based mathematicians gave invited lectures at the 2010 International Congress of Mathematicians held in India in August: Bill Barton, Gaven Martin and André Nies. The only previous New Zealand based mathematical scientist to win this honour was Rod Downey (one of our founding PIs and our first Maclaurin Fellow), when the last time the congress was held, in 2006.

## Knowledge Transfer

- Each of the NZIMA's programmes have encouraged large numbers of students and professional mathematical scientists to take part in their conferences/workshops.
- Postgraduate students have been engaged in specific research projects by each of NZIMA's programmes, with 72 students having been engaged either directly or on programme based research.
- The NZIMA organised or co-sponsored six conferences and instructional workshops in 2010.
- 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 Algorithms involves intensive interaction between mathematics and computer science and applications in biology, ICT and social sciences.
- Our programme on Energy, Wind and Water is an interdisciplinary programme involving mathematical, computational, engineering and environmental sciences.
- We produced two new issues of our newsletter, NZ-IMAgEs, which has the aim of showcasing a selection of mathematical activities across New Zealand, and making these accessible to a wider community.
- Our web-based resource, MathsReach ([www.mathsreach.org](http://www.mathsreach.org)), shows school students and teachers what lies beyond the school curriculum in mathematics and statistics, in terms of professional careers, research activity, hot topics, and interesting and important applications. Eight new videos and 14 articles were prepared for the site during the year.
- The NZIMA website ([www.nzima.org](http://www.nzima.org)) is continually updated with programme information as well as other opportunities and linkages.
- Research findings are announced at national and international conferences, and published in national and international refereed journals.
- A quarterly electronic newsletter of NZIMA activities, appointments and occasional “profiles” of key people (e.g. Maclaurin Fellows, scholars, programme directors) is issued to a wide range of stakeholders.

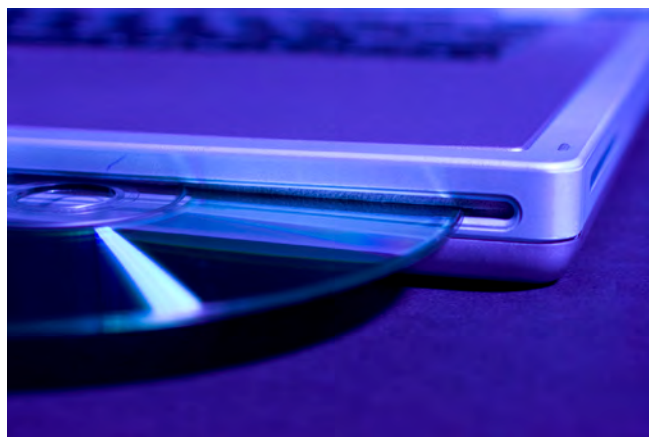
## Contribution to National Goals

- The NZIMA has “lifted the game” for the mathematical sciences in New Zealand, by focusing resources for greatest effect, helping our researchers work at the leading edge of their disciplines, creating new knowledge and also being able to assimilate new knowledge very rapidly, thus strengthening research-led teaching.
- We have developed an outreach programme to lift the profile of the mathematical sciences in the eyes of the public, schools, teachers and students, to increase awareness of possibilities and encourage greater enjoyment and participation in science and other subjects having a quantitative focus.
- Our MathsReach resource is putting across the idea that there is “maths behind every door”, highlighting the fact that mathematics underlies many recent

advances in science, technology and everyday life and that mathematicians are involved in all of these areas.

- Our membership of the IMSI and PRIMA consortia are providing excellent opportunities for New Zealand students to participate in summer schools and other activities organised by our partner institutes overseas.

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



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

# THEMATIC PROGRAMMES

**The following nine programmes have now all been completed:**

- Modelling cellular function
- Logic and Computation
- Numerical methods for evolutionary problems
- Phylogenetic genomics
- Combinatorics and its Applications
- Dynamical Systems and Numerical Analysis
- Geometry: Interactions with Algebra and Analysis
- Mathematical Models for Optimizing Transportation Services
- Hidden Markov Models
- Geometric Methods in the Topology of 3-Dimensional Manifolds
- Partial Differential Equations: Applications, Analysis and Inverse Problems
- Modelling Invasive Species and Weed Impact
- Applications of Mathematics in the Nanosciences

A summary of current programmes follows.

## Algorithms: New Directions and Applications

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

**Programme Directors:** Professor Mike Atkinson (University of Otago), Associate Professor Charles Semple (University of Canterbury), Dr Mark Wilson (University of Auckland) et al

The programme commenced in 2008.

In February 2010, Mark Wilson and Arkadii Slinko organised a workshop on Algorithmic Aspects of Game Theory and Social Choice at the University of Auckland. This coincided with the opening meeting of a new Centre for Mathematical Social Sciences, with Mark Wilson as director. In addition to local participants, a substantial contingent of German researchers specialising in complexity and social choice attended the workshop, as did Professor Edith Elkind (Singapore). The Algorithmics programme supported the visit of Professor Joerg Rothe (Dusseldorf).

A workshop on Matroids and Computation was held at Victoria University of Wellington the week 29 November to 3 December. This workshop aimed to bring together key players in this field internationally (Henry Crapo, Petr Hlineny, Sandra Kingan, Gordon Royle, David Pearce, Rudi Pendavighn, and Stefan van Zwam), to combine their expertise and contributions to various aspects of matroid computation and develop a coordinated approach. The workshop included two other prominent researchers in matroid theory, James Oxley and Dominic Welsh, and was very successful, with a software module being the likely outcome. James Oxley and Dominic Welsh also visited Charles Semple at the University of Canterbury, to work on algorithmic problems in matroid theory.

Mike Atkinson hosted several visitors at the University of Otago to work on permutation patterns: Professor Nik Ruskuc (University of St Andrews), Dr Mathilde Bouvel (University of Paris), Dr Anders Claesson (University of Reykjavik), and Dr Robert Brignall (Open University UK). This work involved development of efficient algorithms to gather data (for providing theoretical insights), as well as new potential approaches to standard and non-standard sorting

Dr Leo van Iersel, a postdoctoral researcher at the University of Canterbury, worked on algorithmic problems in phylogenetics, with funding from the Allan Wilson Centre for Molecular Ecology and Evolution.

Beata Faller successfully completed her PhD at the University of Canterbury on combinatorial, algorithmic, and probabilistic problems in



Beata Faller

phylogenetics. She now holds a postdoctoral fellowship at Eötvös Loránd University in Budapest (Hungary).

Reyhaneh Reyhani continued her PhD project at the University of Auckland on voting games, and is expected to finish in 2012. She and Mark Wilson presented a paper at the workshop COMSOC 2010 in Düsseldorf (Germany) in September).

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

Magnus Bordewich (Durham University) and Bernard Chazelle (Princeton University) have both been interviewed for the NZIMA's MathsReach resource. Their interviews, titled 'Random and algorithmic sampling', and 'iPods, a Flock of Birds and DNA' respectively, are both available at the website <http://www.mathsreach.org.nz/Videos>.

## Conformal Geometry and its Applications

The themes of this programme are conformal and hyperbolic geometry, including symmetries and natural geometric equations, invariants and applications, and nonlinear elasticity and materials science.

**Programme Directors:** Professors Rod Gover (University of Auckland) and Gaven Martin (Massey University) et al

The programme began in 2008 and its main event was a meeting held at Nelson in January 2008, followed up by a workshop on parabolic geometry at Auckland during a focussed research period on parabolic geometry, PDE and prolonged systems (from July to September 2008).



Rod Gover

In 2010 the programme benefitted from visits by several people from the University of Warsaw: Pawel Nurowski, Katja Sagerschnig, Andreas Cap, and Matthias Hammerl, who worked with Rod Gover on various projects and some new directions. Rod Gover also hosted a visit by physicist Andrew Waldron (UC Davis), to work with him on the use of conformal tractor calculus to calculate the asymptotics of a natural boundary problem on conformally compact manifolds, and he continued some joint work with former postdoctoral fellow Paul-Andi Nagy, on conformally Kaehler structures.

Several postgraduate research students were engaged in various aspects of the programme in 2010, some supported by the Marsden Fund or their host university. At the University of Auckland, Matthew Randall (supervised by Gover) completed his MSc on almost projectively Einstein manifolds, Howard Cohl (supervised by ter Elst and Gover) completed his PhD on explicit expansions of fundamental solutions for the Laplace and related equations, and Yuri Vyatkin is continuing his PhD (supervised by Gover) on submanifold structures in conformal geometry. At Massey University, Haydn Cooper (supervised by Martin) is close to completing his PhD on computation discrete hyperbolic geometry.

## **Energy Wind and Water**

This programme's theme is the combined use of simulation, optimization and control algorithms to investigate and solve engineering problems involving energy, wind and water. Emphasis is placed on cross-disciplinary approaches in which simulation techniques, such as computational fluid dynamics, are combined with optimization algorithms to improve engineering designs, or with control algorithms to improve operations.

**Programme Director:** Professor Mike O'Sullivan (University of Auckland) et al

This programme held a one-week workshop on Model Calibration and Quantification of Predictive Uncertainty Using PEST. The workshop was conducted by John Doherty (Queensland), assisted by George Zyvoloski (Los Alamos, USA), and covered some quite sophisticated theory in a very palatable form as well as applications to groundwater and geothermal reservoir models. The workshop was attended by a mixture of academics, students, and working engineers – including two engineers from the Energy Development Corporation in the Philippines, and others from various New Zealand local bodies or consulting companies.

The visit by George Zyvoloski allowed some work with Mike O'Sullivan, on coupled heat and mass transfer and rock mechanics. Also George Zyvoloski made his code FEHM available to several graduate students in the Department of Engineering Science at the University of Auckland, and has invited one of them (David Dempsey) to Los Alamos to work with his group for a short period.



Aspects of this programme and related work are being generously co-sponsored by the Foundation for Research, Science and Technology (FRST), Contact Energy Ltd, and the Energy Development Corporation.

Dr Tiangang Cui (formerly a PhD student supported by the NZIMA) is now working as a postdoctoral fellow, on MCMC methods for calibration of geothermal models. Two other postdoctoral fellows are also involved: Dr Eylem Kaya is working on computer models of the Taupo-Reporoa basin in the Taupo volcanic zone (with funding from FRST), and Dr Adrian Croucher is working on improved techniques for modelling geothermal fields and on models of the Taupo volcanic zone (with funding from FRST and Contact Energy Ltd)

There are three postgraduate students engaged in the programme: PhD students David Dempsey (funded by a TEC scholarship), working on modelling of the development of the Taupo volcanic zone and John O'Sullivan (funded by the Todd Foundation), working on computer modelling of wind flow over complex terrain, and Masters student Jericho Omagbon, working on automatic calibration of geothermal models. John O'Sullivan was selected to take part in the graduate student summer research programme at Stanford University in 2010.

## **Senior Secondary and Undergraduate Mathematical Science in New Zealand**

This programme's overall aim is to investigate the mathematical conditions in the last years of schooling and first years of undergraduate education in New Zealand needed to ensure the provision of a sufficient flow of competent graduates to meet the needs of all sectors of society that require mathematical knowledge and abilities beyond Year 11.

**Programme Director:** Professor Bill Barton (University of Auckland) et al

Following the collection of background data, activities in 2010 focused on creating a vision of these years shared by secondary teachers and undergraduate lecturers.

The programme's main event in 2010 was a two-day conference held at the University of Auckland in April. About 100 people attended (in a ratio of 2:1 teachers/lecturers, with about 10 graduate students) and discussed important themes, including the best possible ideas for enhancements to secondary-tertiary interface. The main speakers



were Prof. Bernard Hodgson (ex-General Secretary of ICMI, from Laval University, Quebec) and Prof Marilyn Goos (President of MERGA, from University of Queensland), Jenny Hudson (President of the NZ Association of Mathematics Teachers), and Megan Clark (Victoria University of Wellington). Bernard Hodgson brought the role of history to the forefront, and Marilyn Goos presented a theoretical framework. Other key participants included Prof. William McCallum (University of Tucson) and Prof. Michèle Artigue (University of Paris VII), whose visits were sponsored by the Royal Society of New Zealand.

In the latter half of 2010, a series of regional workshops were held in Auckland, Rotorua, Manawatu, Wellington, Christchurch and Dunedin (the last one in association with the 2010 NZ Mathematics Colloquium). At these workshops, which were well attended, groups of teachers and lecturers discussed the vision emerging from the conference, and began work on an Action Plan to implement the vision.



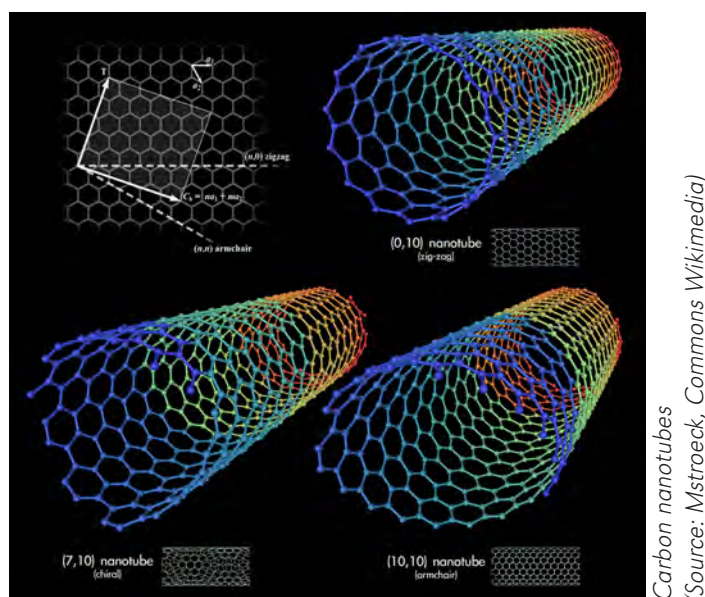
Louise Sheryn

Dr Louise Sheryn completed her research fellowship position in April, but was able to continue to be involved with this programme, thanks to support from the University of Auckland's newly established Community of Undergraduate Learning in the Mathematical Sciences (CULMS). Through this body and its Newsletter, this NZIMA programme has gained further overseas profile, particularly in Australia and the UK.

The programme is now also gaining interest from the Ministry of Education. Angela Jones (Senior Advisor Secondary Outcomes, Ministry of Education) has invited Bill Barton to speak to secondary Heads of Departments in Wellington.

The major output for 2010 was a paper describing the "Emerging Vision", co-authored by Bill Barton, Megan Clark and Louise Sheryn, and accepted for publication simultaneously in the NZ Mathematics Magazine (for a teacher audience) and the NZ Journal of Mathematics (for a lecturer audience). In addition, presentations on elements of the programme were made at the 2010 NZ Mathematics Colloquium, and in Bill Barton's keynote address at a two-day Lecturers Workshop at the 2010 Australian Mathematical Society Meeting.

Of more international significance, the NZ Pipeline Project became a major component of the international IMU/ICMI Pipeline Project. This was reported on at the General Assembly of the International Mathematical Union in Bangalore (India), and again in a special session of the 2010 International Congress of Mathematicians in Hyderabad, in August 2010. In each case the reports highlighted the leadership shown by New Zealand, and made possible by the NZIMA.



## MACLAURIN FELLOWS

### Full Time Fellows

Each year from 2003 to 2008, the NZIMA appointed a New Zealand based mathematical scientist to 12-month Maclaurin Fellowship, to enable them to take time out from their usual occupations and undertake full-time research.

### Visiting Maclaurin Fellows

We have been able to invite a number of distinguished mathematical scientists from overseas to spend short periods of time (three weeks to three months) as visiting Maclaurin Fellows, during which they give public lectures and interact with students and established researchers. In 2010 we hosted Professors Michel Broué (Paris) and David Brillinger (Berkeley) as visiting Maclaurin Fellows.

**Prof. David Brillinger** (from the University of California at Berkeley) visited for a three-week period in March and April 2010. While in New Zealand he gave a give a short course of lectures on Random trajectories: some theory and applications, which was very successful and attracted a large audience from diverse backgrounds. A



very good introduction to this work and its applications in modelling animal movement was published in the April 2010 issue of NZIMAgEs. He also worked with Ross Ihaka (Auckland) on the development of R-based software to implement important techniques from his book Time Series: Data Analysis and Theory, and Ross Ihaka is now putting these together in a systematic package.

**Prof. Michel Broué** (from the University of Paris) stayed in New Zealand for an extended period in January 2010 after the annual NZIMA/NZMRI summer meeting. He gave lectures at a workshop on Algebraic Groups, Finite Groups and Representation Theory at the University of Canterbury (organised by Ben Martin), and in a seminar at the University of Auckland, where he worked with Jianbei An, Heiko Dietrich and Eamonn O'Brien. He also provided stimulus for a new research project for Jianbei An on modular representations of controlled blocks.



Michel Broué (Source: Wikipedia)

## RESEARCH BY CO-DIRECTORS

**Professor Marston Conder's** research (which is supported also by the Marsden Fund) is principally in combinatorial and computational group theory, with applications to the study of discrete objects with maximum symmetry. Particular highlights in 2010 were his discovery of the smallest regular polytopes in all dimensions, construction of infinite families of regular maps that are invariant under reflection, duality, Petrie duality and all of the Wilson 'hole' operators, and proof of a long-standing conjecture about the kernels of skew morphisms of finite groups. He had a full year, supervising six research students and giving invited lectures at four international conferences. He also spent a month in Germany beginning a new project with Juergen Wolfart on quasiplatonic surfaces.

**Professor Vaughan Jones** is continuing to investigate the models defined by himself, Guionnet and Shlyakhtenko. The difficulties associated with controlling the sum of the perturbative expansion led him to introduce the idea of a 'toy model' where one replaces the planar algebra elements that define the Voiculescu trace by an arbitrary sequence of rotationally invariant elements. Positive definiteness becomes a major issue, but there are several natural candidates where one can prove positivity and even hope to say something about the isomorphism class of the von Neumann algebra. In joint work with Guionnet and Shlyakhtenko, this isomorphism class has been determined for a finite depth subfactor and the Voiculescu trace. It is an interpolated free group fact in the sense of Dykema and Radulescu. The classification project of finite depth subfactors up to index five has now been completed, and Jones and his group are refining the proofs and writing up the results. The systematic study of Ocneanu's connections has proved crucial in settling some recalcitrant cases, and has changed the emphasis from the 'quadratic tangle' technique.



*Stock Images: diligent*

## RESEARCH BY POSTGRADUATE STUDENTS

Each of the NZIMA's thematic research programmes involves two or more postgraduate research students, with direct scholarship support from the NZIMA, and some aspects of their work were highlighted earlier in this report.

In addition, the following postgraduate research student projects were supported by the NZIMA in 2010 (based on the merit of the student and the value of their project):

- Haydn Cooper (Massey University) PhD on computational geometry and discrete groups
- Luke Fullard (Massey University), PhD on modelling hydrothermal eruptions: a numerical and experimental study
- Maarten Jordens (Massey University), PhD on distortion functionals and variations
- Javad Khazaei (University of Auckland), PhD on system integration of wind farms via stochastic optimisation
- Jing Liu (University of Auckland), PhD on New methods for estimating effective population size
- Rachael Tappenden (University of Canterbury), PhD on analysis, development and implementation of algorithms for fast image restoration
- Vicki Wang (University of Auckland), PhD on modelling of Left Ventricular Disease
- Lei Zhang (University of Auckland), PhD on optimisation of ambulance relocation and dispatch
- Tong Zhu (University of Auckland), PhD on optimal control and phase transitions in stochastic networks.

The NZIMA has supported 72 postgraduate research students in the mathematical sciences financially since it was established in 2002.



## CONFERENCES, PUBLIC EVENTS AND OTHER ACTIVITIES

In addition to workshops and conferences that were held as part of its thematic programmes the NZIMA used its CoRE funding and status to lend support to the following events held in New Zealand in 2009:

- The annual NZIMA/NZMRI summer meeting took place at Hanmer Springs, from 3 to 10 January 2010, with the theme of Groups, Representations and Number



Marcus du Sautoy

Theory. The organisers were Ben Martin (University of Canterbury) and Eamonn O'Brien (University of Auckland). Instructional lecture courses were given by Martin Bridson (Oxford), Michel Broué (Paris), Persi Diaconis (Stanford), Roger Howe (Yale), Gus Lehrer (Sydney) and Marcus du Sautoy (Oxford). As in previous summer meetings, the lectures were entertaining and captivating, and presented material from the forefront of research not hitherto presented in New Zealand. The meeting was attended by 80 participants, including 27 students.

- Dovetailing with the summer meeting was a wrap-up workshop for the NZIMA's Three-Manifolds programme, on Topological Quantum Field Theory and Knot Homology Theory, at Hahei, 12–18 January 2010. Main speakers at the workshop were Jørgen Andersen (Aarhus), Roger Fenn (Sussex), Mike Freedman (Microsoft), Cameron Gordon (Texas), Stavros Garoufalidis (Georgia Tech), Thang Le (Georgia Tech), Sikimeti Ma'u, (MSRI, Berkeley), Scott Morrison (Berkeley), Clifford Taubes (Harvard), Paul Turner (Fribourg), Matt Visser (VU Wellington), and Kevin Walker (Microsoft). The workshop was attended by 36 mathematicians, including 18 students.
- The WEAR 2010 Anthropometry Conference and Workshop was hosted by the Auckland Bioengineering Institute in February 2010. This conference was attended by 27 participants, including 14 from Australia, the Netherlands, USA, France, Japan and Canada. Sponsorship from the NZIMA enabled participation by emerging researchers. The conference provided a valuable opportunity to promote New Zealand research to a wider audience, and the feedback from participants is that it was a great success. Two keynote presentations were given, one by Dr Kathleen Robinette (Air Force Research Laboratory, USA) and Daisy

Veitch (SHARP Dummies, Australia), and the other by Dr Masaaki Mochimaru (Digital Human Research Center, Japan). In addition, seventeen platform presentations were delivered on topics ranging from “Where is human waist? Definitions, manual measurements compared to scanner measurements” to “Bicubic hermite finite element mesh as a shape descriptor for statistical shape analysis”.

- A workshop on Computational Homology and Dynamics was held at the University of Canterbury in August 2010, organised by Ben Martin, Rua Murray and Mike Plank, and led by Erskine visitor Konstantin Mischaikow (Rutgers University, NJ). The workshop featured a series of one-hour lectures by seven international experts, aimed at postgraduate and senior undergraduate students, and covering topological methods for analysing data sets that arise from dynamical systems, and their applications to gene regulation, neural networks, image processing, and fluid flow. Sponsorship by the NZIMA was particularly helpful in supporting the participation of students.
- A one-day conference on Women in Statistics was held at Victoria University of Wellington on 20th October (World Statistics Day). Organised by Sharleen Forbes (Statistics New Zealand and VU Wellington), the meeting attracted over 50 people from a range of backgrounds. The Hon. Pansy Wong, Minister of Women’s Affairs, opened the conference and enthusiastically promoted the importance of statistics across a wide range of activities, including many of direct relevance to women. The main speakers were Natalie Jackson (Educating Rita and Other Efficiency Gains), Lisa Davies, (Using statistics to inform Maori development policy), Sharleen Forbes (Old Data: new ways of seeing it), Megan Clark (Less is More), Jennifer Brown (Going Green: How statistics helps manage New Zealand’s environment), and Rachael Milicich (Statistics and Me). For more details, see <http://www.victoria.ac.nz/sog/about/news.aspx>
- The fourth New Zealand Mathematics & Statistics Postgraduate Students (NZMASP) Conference was held at Westport, 22–25 November 2010. The meeting was organised by Shannon Ezzat, Anna MacDonald and Rachael Tappenden (from the University of Canterbury), with help from others around



Jennifer Brown

New Zealand, and sponsorship from the NZIMA. As in previous years, the conference was well attended, by 34 participants enrolled for masters and doctoral degrees at New Zealand universities, with approximately one third from each of applied mathematics, pure mathematics and statistics. The student-run and organised conference was a great success. Plenary lectures were given by Gaven Martin (Massey University at Albany) who spoke about quasiregular mappings, curvature and dynamics, Esther Meenken (Plant and Food Research) who spoke about the transition from academia to industry, and David Wall (University of Canterbury) who talked about Harry Potter and his invisibility cloak!

Participants enjoyed the relaxed atmosphere and supportive environment in which to network among fellow postgraduates, gain new and up-to-date knowledge about cutting edge research by their peers, and describe their own research in a well thought-out, high quality presentation. Awards for the best presentations were made to Emily Harvey (University of Auckland), Edoardo Perischitti (University of Auckland), and Anna MacDonald (University of Canterbury), with the “people’s choice” award going to Timothy McKenzie (Victoria University of Wellington). Also, for the first time, a session was held to discuss the future and benefits of the NZMASP conference. This provided a great opportunity for delegates to reflect and give feedback.



NZMASP 2010 participants



## Public Events and Outreach

Seven interviews were added to the *MathsReach* website ([www.mathsreach.org](http://www.mathsreach.org)) in 2010. These were:

- Claire Postlethwaite: Maths in nature
- Colin Fox: Antarctic sea ice and maths
- Heikki Haario: Inverse problem solving
- Jorg Frauendiener: Ripples in the fabric of space time
- Michael Albert: International Mathematical Olympiad
- Mike Atkinson: Become a Sudoku expert!
- Andres Christen: Paleoecology and climate change.



Claire Postlethwaite

Our first short documentary, on optimising air crew scheduling with Air New Zealand, was put up this year. We hope to add more documentaries in the next few months.

In addition, 14 new articles were posted on *MathsReach*. These are excerpted from our twice yearly newsletter, *NZ-IMAg*es.

- Luke Fullard, Tammy Lynch: Predicting hydrothermal eruptions
- David Brillinger: Keepers of the flame
- Jonathan Leaver: Counting on Power
- Persi Diaconis: The magic of numbers
- Barbara Holland: Hybrids and genetic trees
- Practical maths: Crocheting the hyperbolic plane
- Robin Averill: Maori and Pasifika maths students
- Notable Maths Problems: Yang-Mills Theory and Mass Gap
- Ivan Reilly: Breaking our Olympiad records

- Chris Wild, Maxine Pfannkuch, Matt Regan: World-leading statistics education
- Mik Black, Sharleen Forbes, Marti Anderson, Ross Ihaka, Jennifer Brown, Richard Arnold, Bridget Robson, Rachel Fewster, Mark Wohlers, Tony Blakely: Statistics opportunities
- Ben Green: Patterns in prime numbers
- Golbon Zakeri, Javad Khazaei: Allowing for wind power
- Notable Maths Problems: Hodge Conjecture.

## AWARDS AND HONOURS

**The following is a selection of awards and honours won by NZIMA people in 2010:**

- Three people closely involved in activities of the NZIMA since 2002 gave invited lectures at the 2010 International Congress of Mathematicians, held in India in August: Bill Barton, Gaven Martin and André Nies (see below). The only previous New Zealand based mathematical scientist to win this honour was Rod Downey (one of our founding PIs and our first Maclaurin Fellow), when the last time the congress was held, in 2006.
- Bill Barton (director of our programme in Mathematics Education) began a three-year term as President of the International Commission on Mathematical Instruction (ICMI), from 2010 to 2012. He also gave an invited public lecture at the 2010 International Congress of Mathematicians. His lecture, on ‘Where is mathematics taking us?’, attracted an audience of hundreds of students and teachers, and was highlighted on the cover of the November 2010 issue of the Notices of the American Mathematical Society.

John Butcher (Source: Wikipedia)



- John Butcher (one of our founding PIs and director of our programme on Numerical Methods for Evolutionary Problems) won the inaugural Jones Medal of the Royal Society of New Zealand in 2010, for lifetime achievement in the mathematical sciences. This award was made to John in recognition of his exceptional work on numerical methods for the solution of ordinary differential equations, especially in

developing the foundations of the modern theory of Runge-Kutta methods, and his leadership in the development of the mathematical sciences in New Zealand. Also John was elected a Fellow of the Society for Industrial and Applied Mathematics (SIAM), and is the first ever New Zealander to win this honour.

- Marston Conder (NZIMA Co-Director) was awarded a renewal of his Fellowship of the Alexander von Humboldt Foundation for a one-month visit to Germany in May 2010. He was also appointed as one of three Moderators for the 2012 Quality Evaluation component of the PBRF (the Performance Based Research Fund).
- Len Cook (Board chair) was elected a Life Member of the NZ Statistical Association.

- Rod Downey (one of our founding PIs and our first Maclaurin Fellow) and André Nies (see later) were joint winners with Denis Hirschfeldt and Sebastiaan Terwijn of the 2010 Shoenfield Prize, awarded by the Association for Symbolic Logic, for their article 'Calibrating randomness' (published in the Bulletin of Symbolic Logic, vol. 12, 2006). Also Rod Downey's PhD student Adam Day has won a prestigious Miller Fellowship at the University California at Berkeley.



André Nies

- Shaun Hendy (director of our programme on Applications of Mathematics in the Nanosciences) won the 2010 Research Medal of the NZ Association of Scientists.
- Peter Hunter (one of our founding PIs and now a member of our new Governing Board) was made a Member of the Order of New Zealand (MNZM) in the New Year Honours List, and been named an Honorary Fellow of the Institution of Professional Engineers New Zealand (IPENZ).
- Ross Ihaka (University of Auckland) and Robert Gentleman (Genentech, formerly also at the University of Auckland), whose work in creating the "R" system for statistical computing was featured on the front page of Issue 3 of our NZ-IMAgEs bulletin, won the Statistical Computing and Graphics Award from the American Statistical Association.

- Gaven Martin (one of our founding PIs and co-director of two of our thematic programmes) gave an invited lecture at the 2010 International Congress of Mathematicians. He was also a Visiting Fellow at the Hausdorff Institute in Bonn (Germany) and the Institute for Mathematical Sciences (Singapore), and was appointed as a member of a US National Science Foundation funding panel.
- André Nies (a member of our Logic and Computation programme committee) was elected a Fellow of the Royal Society of New Zealand. Also he won the NZ Mathematical Society's annual Research Award for 2009, and gave an invited lecture at the 2010 International Congress of Mathematicians.
- Charles Semple (co-director of our programme in Algorithmics) won the New Zealand Mathematical Society's annual Research Award for 2010.
- Rachael Tappenden (one of our NZIMA scholarship holders based at the University of Canterbury) won the 2010 Aitken Prize, for the best lecture given by a student at the 2010 New Zealand Mathematics Colloquium.
- Geoff Whittle (one of our PIs and previously one of our 12-month Maclaurin Fellows) was selected by the London Mathematical Society and NZ Mathematical Society as its first Aitken Lecturer, and will make a lecture tour in the UK in 2011.



Rachael Tappenden

## 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](http://www.fields.utoronto.ca/aboutus/IMSI.html)

The NZIMA is a founding member of the 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 consortium of mathematical sciences institutes involves improved networking, coordination of activities, training (including summer schools),

infrastructural assistance, sharing of expertise, and pooling of resources. More information about PRIMA and its intended activities can be now be found on its website <http://www.primath.org/>. Marston Conder is on the Steering Committee of PRIMA, which will hold its second major Congress in 2013 in Shanghai (China).



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

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

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

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

## **GOVERNANCE AND MANAGEMENT**

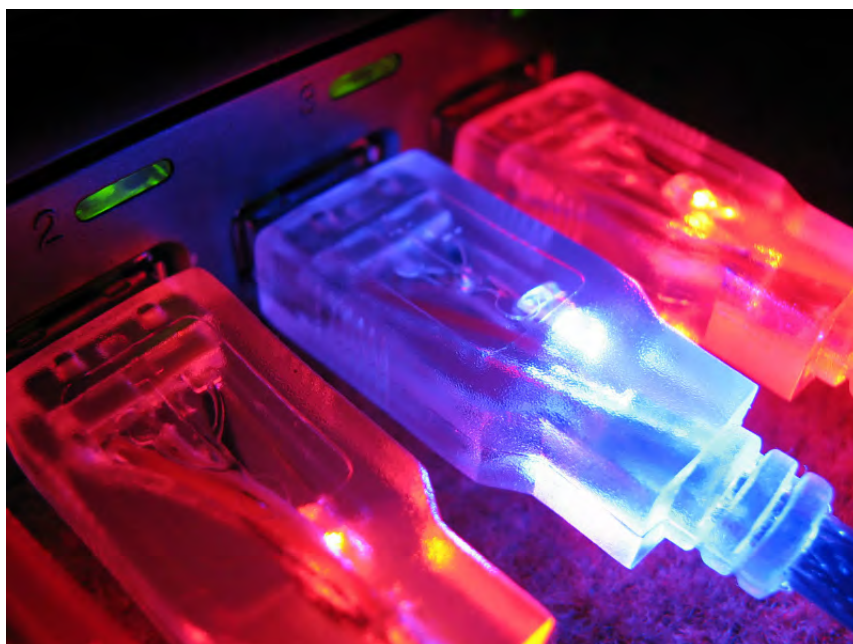
The NZIMA's previous Governing Board completed its term in 2008. The new board met for the first time in March 2010, then again in April. Key ongoing challenges for this new board are to formulate strategies for the NZIMA to build its activities, funding, profile and outreach, with the additional challenge of dealing with the outcome of the 2006/07 CoRE selection round.

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

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

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

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



Stock Images: diligent



## 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 2010 year

**Funds balance at start of 2010** \$ 853,277

Income	Actual	Budget	Variance
CoRE Funding	\$ 611,668	\$ 611,667	\$ 1
Other income	4,494	0	4,494
<b>Total Income</b>	<b>\$ 616,162</b>	<b>\$ 611,667</b>	<b>\$ 4,495</b>

#### Expenditure

Salaries			
Director & Principal Investigators	\$ 101,244	\$ 72,500	\$ (28,744)
Associate Investigators	33,765	45,000	11,235
Postdoctoral Fellows	123,809	68,750	(55,059)
Research/ Technical Assistants	0	0	0
Others	34,261	24,500	(9,761)
<b>Total Salaries (a)</b>	<b>\$ 293,079</b>	<b>\$ 210,750</b>	<b>\$ (82,329)</b>
Other Costs			
Project Costs	\$ 141,528	\$ 48,417	\$ (93,111)
Travel	79,206	20,000	(59,206)
Postgraduate Student Support	293,958	118,000	(175,958)
Project Overheads	94,579	105,375	10,796
Host Overheads*	119,479	105,375	(14,104)
Equipment depreciation	0	0	0
Rental - equipment	1,769	3,750	1,981
Subcontractors	0	0	0
Extraordinary expenditure	0	0	0
<b>Total Other Costs (b)</b>	<b>\$ 730,519</b>	<b>\$ 400,917</b>	<b>\$ (329,602)</b>
<b>Total Expenditure</b>	<b>\$ 1,023,598</b>	<b>\$ 611,917</b>	<b>\$ (411,931)</b>

**Surplus/Deficit** \$ (407,436) 0

**Funds balance at end of 2010** \$ 445,840

\*Host overheads made up of

- Univ Auckland indirect costs	\$ 82,354
- NZIMA admin/office costs	37,125

## RESEARCH PUBLICATIONS

The following is a selection of publications in 2010 by researchers supported by or involved with the NZIMA during recent times. Note that many of these will also appear in the lists of publications of other Departments or Centres/Institutes in the University of Auckland, or in those for some other New Zealand universities.

### Articles in Refereed Journals and Refereed Conference Proceedings

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Aikin, Jeremy; Chun, Carolyn; Hall, Rhiannon; Mayhew, Dillon: Internally 4-connected binary matroids with cyclically sequential orderings. *Discrete Math.* 310 (2010), no. 1, 92–108.

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