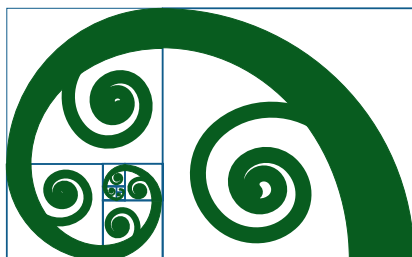


New Zealand Institute of Mathematics and its Applications (NZIMA)

Annual Report 2011



New Zealand Institute of
Mathematics & its Applications

CONTENTS

OVERVIEW FROM CHAIR OF THE NZIMA BOARD	2
REPORT FROM DIRECTORS AND EXECUTIVE COMMITTEE	4
PROGRESS WITH RESPECT TO CoRE FUND OBJECTIVES	7
THEMATIC PROGRAMMES	11
RESEARCH BY POSTGRADUATE STUDENTS	14
AWARDS AND HONOURS	18
INTERNATIONAL LINKAGES	20
GOVERNANCE AND MANAGEMENT	21
FINANCIAL STATEMENT	24
RESEARCH PUBLICATIONS	25

OVERVIEW FROM CHAIR OF THE NZIMA BOARD

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

This is an interesting point in the history of the NZIMA. We have now put in place the foundation of an entity that can earn a justifiable share of the resources available overall for science in New Zealand, and be supported by the sources most directly benefiting from its work. Progress has been slower than initially assumed in getting support among those who have an interest in the shape and scope of any future institute that might succeed the NZIMA, but this has led us to a deeper



Len Cook

understanding and stronger belief in the need for finding ways to retain a New Zealand-wide institute focused on networking across the mathematical and statistical sciences.

We recognise that this means that any future incarnation of this institute will be more visibly focused on applied research, and that its potential to bring together those focused on pure and applied mathematics and statistics around New Zealand will remain a fundamental cornerstone. The scope of applications is very broad, and we have recognised that the services sector, including public services, is rich with opportunity.

As we recognised last year, in New Zealand the establishment of CoREs has been one of the few ways in which 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 two co-directors and the Board of the NZIMA have been working to have the value of these features recognised. Continued uncertainty about the future policy and intended regular review of CoREs has been somewhat frustrating. We simply do not know when another CoRE funding round will take place.

The co-directors have found transitional support from several organisations, but this does not obviate the need to demonstrate the long-term value of a future Institute. As I noted last year, I have never been more certain of how important the mathematical, statistical and computational sciences are for New Zealand's future, and for the

choices that we want to have about how we generate wealth. We simply must be convincing about the need to invest wisely and bolster the mathematical and statistical capability of this country. Now that the organisation of science has settled down, we need to affirm 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 continued to bring renewed vigor to demonstrating the value of the work of the NZIMA 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. It certainly enabled us to obtain support in the meantime to continue at a reduced level after the 2011/12 year.

The Board is also most appreciative of the efforts of many of the NZIMA's investigators, who have contributed their thoughts in the various requests from the co-directors for ideas and advice. This will be the final year when Professor Marston Conder will be co-Director, and his efforts to leave a legacy to us of a model relevant to a future institute have been a great contribution, alongside the achievements that NZIMA has already attained. We have been fortunate to have had in this role one of the country's most valuable science leaders, at this time of profound challenge to the place of the institute.

Len Cook

REPORT FROM DIRECTORS AND EXECUTIVE COMMITTEE

This is the final annual report that we will write for the NZIMA under the terms of its two contracts with New Zealand's Tertiary Education Commission (TEC) as a Centre of Research Excellence from 2002 to 2011.

As such, we feel it is highly appropriate to reflect on the achievements of the NZIMA over the last ten years.

There is no doubt that the NZIMA has been one of the best things to happen for the mathematical sciences in New Zealand. Benefits from the NZIMA's programmes and other activities have included the following:

- A structured approach to building up teams and networks across seven independent universities and collaborating organisations
- Visits to New Zealand by top quality researchers across a wide range of fields
- Increased access to the international stock of knowledge
- Attraction of leading international figures (through the status of the NZIMA and the growing reputation of its activities)
- Membership of the international consortia IMSI and PRIMA
- Ability to go beyond 'business as usual' and catalyse new activity
- Broader range of activity than typically pursued in individual research projects
- Bringing together individuals who would not otherwise have collaborated
- Development of recognised young achievers as potential research leaders
- New opportunities for our postgraduate students and emerging researchers
- Establishment of a network of women in the mathematical sciences
- Integration of researchers from smaller or isolated entities with limited funding
- World class research in a number of key fields and their applications
- Cross-pollination of experience and application
- A significant increase in the quality and quantity of publication by New Zealand researchers in top international journals
- Special issues of international journals highlighting research in New Zealand

- Recognition by a very large number of awards, honours and invitations
- Consequent benefits of enhanced international reputations, such as journal editorships, exchange visits, and research grant coordination
- Recognition by world class researchers that New Zealand is a very good place to work (despite salary and other resource limitations).

But the benefits achieved by the NZIMA go well beyond the mathematical sciences.

Of particular value has been the NZIMA's outreach to the wider education and scientific community, through public lectures and the NZ-IMAgEs and MathsReach resources. The latter have introduced (for the first time) a high level of nationwide communication of what goes on in New Zealand in the mathematical sciences, including beneficial application of the mathematical sciences to other disciplines and to the New Zealand economy, environment and society.

Good examples of interdisciplinary benefits include these:

- Development of new computational software for evolutionary biologists
- Enhanced clinical research procedures
- New knowledge and methods for molecular biology (at cellular and organ level)
- New PDE methods in engineering (hydrology and process monitoring), wildlife management, statistics, computer vision, and climate modelling.

Wider benefits to the New Zealand economy, environment and society have included these, to name just a few:

- Cost savings of \$15m pa to Air New Zealand (through optimisation work by David Ryan's group)
- Energy modelling used in Contact Energy's \$1bn expansion plans (through Mike O'Sullivan's group)
- An 18% increase in profitability for Pacific Horizon (through work by PhD student Eyal Loz)
- Improvements in efficiency of daily milk collection for Fonterra (15,000 farms)
- Optimisation of electricity generation and charging, through work by the Energy Power Optimisation Centre (EPOC) established by Andy Philpott and his team
- Improved methods for displaying evolutionary data (David Bryant) and measurement of biodiversity (Mike Steel)

- ‘Fast fix’ GPS used on light-weight wildlife tags for tracking endangered bird species (Jennifer Brown et al)
- Increased use of evidence in clinical diagnoses, used to select patients for high cost procedures and tests (Nic Smith et al).

Other benefits will continue to accrue as fundamental research achievements and the development of new skills and knowledge take effect in the future.

A large proportion of the benefits highlighted above would not have been achieved without having the NZIMA. Others would have required significant additional resourcing to achieve under traditional arrangements.

In reality, they serve to further underline our disappointment with the decision made by the Tertiary Education Commission in 2007 to wind down the status and funding of the NZIMA as one of New Zealand’s Centres of Research Excellence.

Overall, we have built up a strong platform of research excellence and invested positively in the next generation of mathematical scientists, and we look forward to New Zealand’s being able to take advantage of these in the near future.

Finally, we would like to thank all those who have been involved in the NZIMA’s operations over the last ten years.

We’d especially like to thank Len Cook (chair of our Governing Board), directors of all of our seventeen programmes and ten summer workshops, all others who have led particular activities, Margaret Woolgrove (our excellent Research Manager), Bill Barton and Judy Paterson (who have helped with outreach to schools), Jenny Rankine for her marvellous assistance in producing NZ-IMAgEs, Neil Morrison, Rob Carter and John Glass for their work with Margaret on our MathsReach resource, and all those who have voluntarily given their time and expertise to be interviewed for either MathsReach or NZ-IMAgEs.

Also we’d like to thank heads of departments and leaders of professional societies in the mathematical sciences in New Zealand for their involvement in various ways, members of our International Scientific Advisory Board for their valuable advice in helping us decide on thematic programmes and other activities, the University of Auckland and the NZ Mathematics Research Institute (Inc.) for their role in jointly establishing the NZIMA and helping to guide its development, and all current and former members of the NZIMA Board for the oversight role they have played.

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:

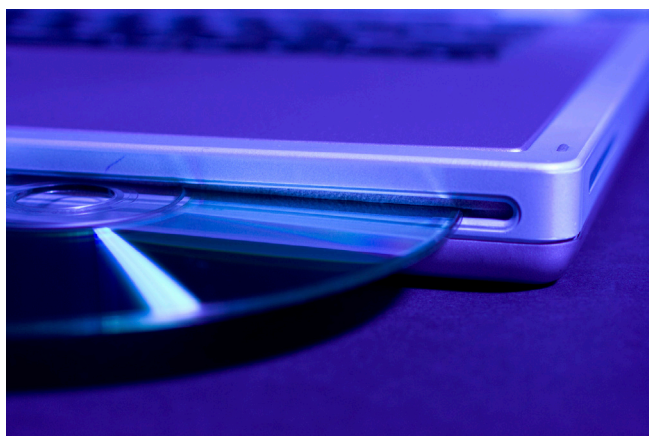
- is of excellent (world-class) quality
- leads to knowledge transfer, and
- is focussed on New Zealand's future development.

Below are some of the highlights of the NZIMA's activities and achievements in 2011 that show we are meeting these objectives. Further details can be found elsewhere in this report.

Research Excellence

Our programmes have brought 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 and created significant advances in knowledge and applications.

Researchers involved with the NZIMA published a large number of articles in some of the world's top mathematics journals in 2011, including *Advances in Mathematics*, *Journal für die Reine und Angewandte Mathematik*, *Journal of Algebra*, *Journal of Combinatorial Theory, Series A*, *Journal of Combinatorial Theory, Series B*, *Journal of Fluid Mechanics*, *Journal of Functional Analysis*, *Journal of Geometry and Physics*, *Nonlinearity*, *SIAM Journal on Applied Mathematics*, *SIAM Journal on Numerical Analysis*, *Transactions of the American Mathematical Society*.



Stock Images: MarkCoffeyPhoto

NZIMA researchers have continued to win numerous honours and awards in 2011, including the following:

- Hector Medal of the Royal Society of New Zealand (Rod Downey)
- Pickering Medal of Royal Society of New Zealand (David Ryan)
- Edgeworth-Pareto Award (Matthias Ehrgott)
- Henry J Ramey (Jr.) Geothermal Reservoir Engineering Award (Mike O'Sullivan)
- 2011 Van Wijngaarden Award (John Butcher)
- Campbell Award of the NZ Statistical Association (Alastair Scott)



Matthias Ehrgott

Knowledge Transfer

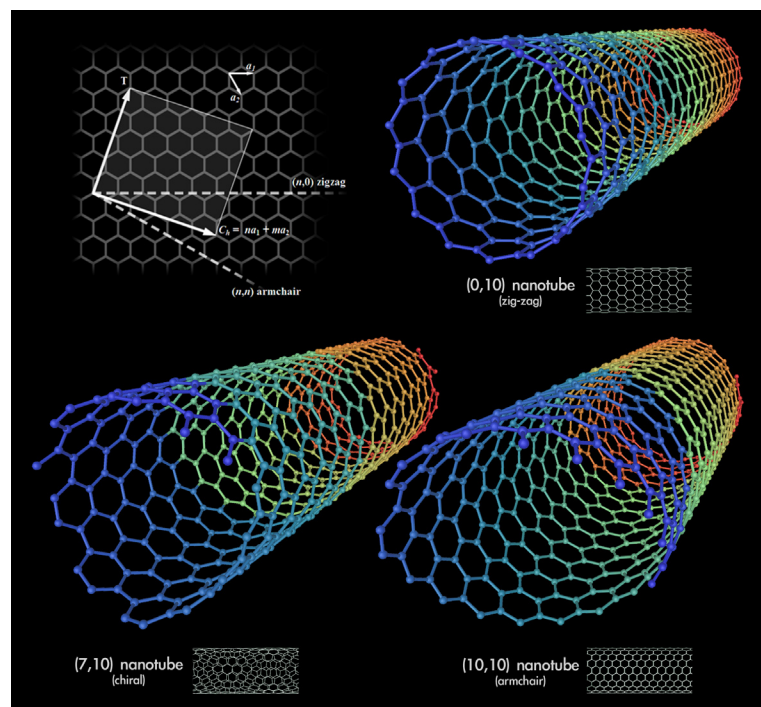
- Each of the NZIMA's programmes have encouraged large numbers of students and professional mathematical scientists to take part in their conferences/workshops.
- Postgraduate students have been engaged in specific research projects by each of NZIMA's programmes, with 72 students having been engaged either directly or on programme based research.
- The NZIMA organised or co-sponsored five conferences and instructional workshops in 2011.
- 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), 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. Nine new videos and 17 articles were prepared for the site during the year.
- 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. Visiting 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.

- We are undertaking research that has potential and actual benefits for New Zealand's economy, society, and environment, as illustrated in previous reports, plus the following:
 - 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.



Carbon nanotubes
(Source: Mstroeck, Commons Wikimedia)

THEMATIC PROGRAMMES

Seventeen programmes have now 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
- Algorithms: New Directions and Applications
- Conformal Geometry and its Applications
- Energy Wind and Water
- Senior Secondary and Undergraduate Mathematical Science in New Zealand

Brief reports on the last two programmes are given below.

Energy Wind and Water

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

Dr Tiangang Cui (formerly a PhD student supported by the NZIMA) was engaged as a postdoctoral fellow to work on MCMC methods for calibration of geothermal models. Two other postdoctoral fellows were also appointed: Dr Eylem Kaya worked on computer models of the Taupo-Reporoa basin in the Taupo volcanic zone (with funding from FRST/MSI), and Dr Adrian Croucher worked on improved techniques for modelling geothermal fields and on models of the Taupo volcanic zone (with funding from FRST/MSI and Contact Energy Ltd)

Three postgraduate students were engaged in the programme in 2011: PhD students David Dempsey (funded by a TEC scholarship), working on modelling of the development of the Taupo volcanic zone; PhD student John O'Sullivan (funded by the Todd Foundation), working on computer modelling of wind flow over complex terrain; Masters student Jericho Omagbon (funded by the NZIMA), working on automatic calibration of geothermal models.

Many aspects of this programme and related work were generously co-sponsored by the Foundation for Research, Science & Technology (now the NZ Ministry of Science & Innovation), Contact Energy Ltd, and the Energy Development Corporation.

Senior Secondary and Undergraduate Mathematical Science in New Zealand

This programme's overall aim was 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 2011 continued to focus on creating a vision of these years shared by secondary teachers and undergraduate lecturers.

Dr Louise Sheryn was engaged in the programme, with 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 also gained interest from the Ministry of Education. Angela Jones (Senior Advisor Secondary Outcomes, Ministry of Education) has invited Bill Barton to speak about it to secondary Heads of Departments in Wellington.

Presentations on elements of the programme were made at the DELTA 2011 Conference (on the teaching and learning of undergraduate mathematics and statistics) in Rotorua in November 2011, and the 2011 NZ Mathematics Colloquium in Auckland in December 2011.

RESEARCH BY POSTGRADUATE STUDENTS

Each of the NZIMA's thematic research programmes has involved two or more postgraduate research students, with direct scholarship support from the NZIMA.

In addition, several postgraduate research student projects were supported by the NZIMA in 2011 (based on the merit of the student and the value of their project).

Student projects supported in 2011 included these:

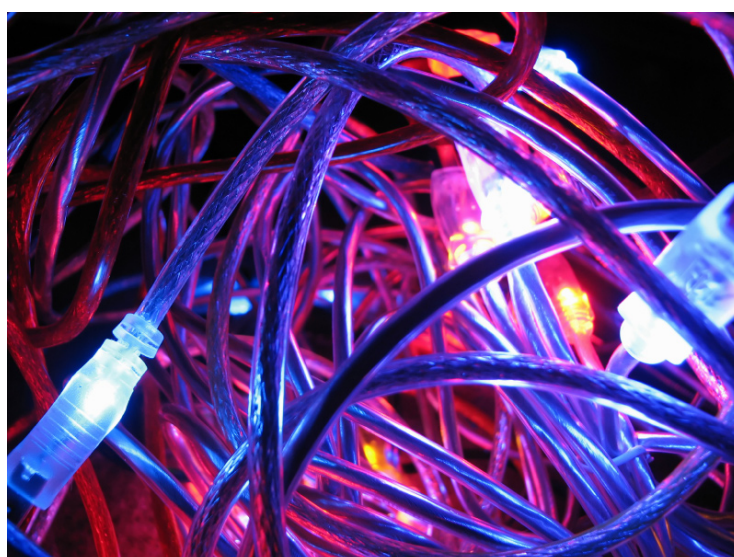
- Haydn Cooper (Massey University) PhD on computational geometry and discrete groups
- Luke Fullard (Massey University), PhD on modelling hydrothermal eruptions: a numerical and experimental study
- Ishrat Imran (University of Auckland), PhD on schedule recovery for Air New Zealand's domestic operations
- 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
- Jericho Omagbon (University of Auckland), Masters on automatic calibration of geothermal models
- Rachael Tappenden (University of Canterbury), PhD on analysis, development and implementation of algorithms for fast image restoration
- 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, VISITS 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 several events in New Zealand in 2011. Among these were the following:

- The annual NZIMA/NZMRI summer meeting took place in Raglan from 9 to 14 January 2011, with the theme of Dynamical Systems. The meeting was organised by Rua Murray (University of Canterbury), Vivien Kirk (University of Auckland) and Arno Berger (University of Alberta), and was attended by around 60 participants, including 22 students and 25 international visitors.
- We hosted a three-week visit by Professor Jan Saxl, from the University of Cambridge (UK), as our last visiting Maclaurin Fellow with support from CoRE funding. Professor Saxl is a world expert on group theory, and an article on his work appeared in Issue 10 of NZ-IMAgEs (see above). His visit was hosted by Ben Martin (University of Canterbury) and Eamonn O'Brien (University of Auckland).
- The NZIMA has been a major sponsor of the NZ mathematical olympiad training scheme. Each year, New Zealand sends a team of six high school students to the International Mathematical Olympiad. In 2011, the New Zealand team posted another great performance, at the 52nd IMO (held in July in Amsterdam). The team returned with two silver medals, two bronze medals, and two honourable mentions, and the team's top scorer, James Allen, came within one point of winning New Zealand's second ever gold medal. The overall result put NZ in 29th position among the 101 different countries taking part - just four places and



ISTock Images: diligent

only two points behind Australia (but with a higher top score). Once again this is a tribute not only to the students themselves, but also to the team leaders, and all the teachers and academics across the country who voluntarily participate with the selection and training of students in the olympiad programme.

- Volcanic DELTA 2011 (the 8th Southern Hemisphere Conference on the Teaching and Learning of Undergraduate Mathematics and Statistics) took place at Rotorua, from 27 November to 2 December 2011, and was attended by 155 delegates, including 66 from New Zealand and 89 from overseas. This meeting was sponsored by the NZIMA both directly and through its thematic programme on “Senior Secondary and Undergraduate Mathematical Science in New Zealand”.
- The 12th Asian Logic Conference (held at Victoria University of Wellington, 15-20 December 2011) was partially supported by the NZIMA. It attracted an outstanding range of invited speakers, and 102 participants, including 29 from NZ.

Public Events and Outreach

Five interviews were added to the *MathsReach* website (www.mathsreach.org) in 2011. These were:

- Golbon Zakeri: Wind and power generation
- Martyn Nash: Mapping medical imaging
- Rosalind Archer: Underground carbon dioxide
- Andrew Pullan: Stomach pacemakers
- Cameron Walker: Dealing with data

Two short documentaries were also added:

- Transatlantic rowing and mathematics
- The Honeycomb Conjecture

The latter is our first “MathsBytes” programme, a short piece aimed primarily at a primary and intermediate school audience, that was debuted at the University of Auckland’s web-based Incredible Science this year.

In addition, 18 new articles were posted on *MathsReach*. These are excerpted from our twice yearly newsletter, *NZ-IMAg*es.

- Following in Klein's footsteps: Bill Barton
- Flows of mathematics students: Bill Barton
- Official statistics up with the best: Len Cook
- Statistics are working: Mik Black, Stephen Haslett, Richard Arnold, Rachel Fewster
- Abstract beauty: Jan Saxl
- Maths in psychology: Sue Street
- Speeding medical images: Rachael Tappenden
- Luminiferous aether: Matt Visser, Nick Wyatt
- Notable maths problem: the Birch and Swinnerton-Dyer Conjecture
- The Maths/Art Nexus: Peter James Smith
- Asking Unpopular Questions: Megan Clark
- Census at school: Rachel Cunliffe
- Computing Symmetries Networks and Maps: Marston Conder
- Examples from C^* : Astrid an Huef
- Crocheted Chaos: Hinke Osinga
- Variety in Statistics: Thomas Lumley
- Multiplying Matroids: Dillon Mayhew
- Notable maths problem: Does there exist a projective plane of non prime-power order?



Rachael Tappenden

AWARDS AND HONOURS

The following is a selection of awards and honours won by NZIMA people in 2011:

- John Butcher (one of our founding principal investigators) won the 2011 Van Wijngaarden Award from the Centrum Wiskunde & Informatica (CWI) in Amsterdam, in February 2011, for his eminence in the fields of mathematics and computer science.
- Marston Conder (NZIMA Co-Director) was selected by the American and New Zealand Mathematical Societies as the first ‘Maclaurin Lecturer’, under a new cooperative venture between the two societies, and he will make a lecture tour of universities in the USA in 2012/13. He was also appointed one of a small number of non-European “Associate Partners” in a new EuroCoRE (Centre of Research Excellence), funded by the European Science Foundation, in the priority area of “Graphs in Geometry and Algorithms.
- In addition, has was appointed a Distinguished Professor at the University of Auckland, and awarded a two-year James Cook Fellowship by the Royal Society of New Zealand, from March 2012.
- Adam Day, a former student of Rod Downey at Victoria University of Wellington who took part in Algorithms programme (and our summer meeting in January 2009), won the Royal Society of NZ’s 2011 Hatherston Award, for the best published paper in earth, physical, mathematical or information sciences by a university PhD student in NZ, for his excellent single-author paper on “Increasing the gap between descriptive complexity and algorithmic probability”, which was published in the prestigious Transactions of the American Mathematical Society.
- Rod Downey (one of our founding PIs and our first Maclaurin Fellow) won the Hector Medal of the Royal Society of NZ in 2011, for his outstanding and internationally acclaimed work in recursion theory, computational complexity, and other aspects of mathematical logic and combinatorics.



Adam Day

- Matthias Ehrgott (co-director of our programme on Mathematical Models for Optimizing Transportation Services) won the Edgeworth-Pareto Award from the International Society on Multiple Criteria Decision Making. This award was presented to Matthias at the 21st International Conference on Multiple Criteria Decision Making, at Jyväskylä (Finland) in June 2011.
- Peter Hall (University of Melbourne), a member of the NZIMA's International Scientific Advisory Board, won a prestigious 2011 Australian Laureate Fellowship from the Australian government.
- Mike Hendy (one of our founding PIs) has been awarded a 6-month Alfried Krupp Senior Fellowship at the Alfried Krupp Wissenschaftskolleg, in Griefswald, Germany, for the (northern) summer, 2012.
- Shaun Hendy (Director of our programme on the "Mathematics of the Nanosciences") has been elected incoming President of the New Zealand Association of Scientists. He also won the inaugural Massey University Distinguished Young Alumni Award, for alumni aged 35 and under.
- Vaughan Jones (NZIMA Co-Director) has been appointed to a Distinguished Professorship at Vanderbilt University, Tennessee, from August 2011. Vaughan will continue to visit New Zealand once or twice each year, and especially for the annual NZIMA/NZMRI summer meetings.
- Javad Khazaei, one of the PhD students supported by the NZIMA on a merit basis over the last three years, has been offered a very generous postdoctoral position at Princeton University in the USA. Javad's work with his supervisor Golbon Zakeri (Engineering Science, University of Auckland), was featured in issue 9 of our "NZ-IMAgEs" publication in October 2010.
- Mike O'Sullivan (one of our founding PIs, and director of our thematic programme on "Energy, Wind and Water") has won the Henry J. Ramey Jr Geothermal Reservoir Engineering award from the Geothermal Resources Council (GRC), for "outstanding achievements in the field of geothermal reservoir engineering". He received the award at the GRC's annual meeting in October 2011, at San Diego, California.
- David Ryan (one of our founding PIs) won the 2011 Pickering Medal from the Royal Society of NZ, for his work on developing technology which is at the heart of optimisation software used worldwide for solving complex logistics problems, such as airline scheduling. David is a strong advocate for the use of

mathematical optimisation techniques to solve problems of significant industrial importance, and is well known for his success in this field, for example in scheduling flight crews (that has resulted in savings to Air New Zealand of more than NZ\$ 15 million per year).

- Alastair Scott (a founding PI of the NZIMA) won the Campbell Award for 2011 from the NZ Statistical Association, in recognition of his outstanding contribution to the promotion and development of statistics. [This award was made jointly and posthumously also to Roger Littlejohn (who was co-director of our programme on Hidden Markov Models, but sadly died in March 2011 after a short illness).]
- Matt Visser (another of our principal investigators) has been awarded a two-year James Cook Fellowship by the Royal Society of New Zealand. Matt will use this for research on the interface between quantum physics and gravity, involving Einstein's theory of general relativity.

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 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 Governing Board met in February 2011 in person and discussed matters by electronic mail during the year. 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.

Over the last ten years our Advisory Board has assisted 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 various other committees have assisted 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 special events.

The two Co-Directors have interacted 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).

NZ Mathematical Sciences Council: In the mid 1990s, representatives of various professional societies in the mathematical sciences in NZ got together to form a council, which then became the standing committee of the Royal Society of NZ for Mathematical and Information Sciences. Over the next 15 years, this committee formed a very good vehicle for effective communication and cooperation between the NZ Association of Maths Teachers, the NZ Mathematical Society, the NZ Statistical Association and the Operations Research Society of NZ, as well as linkages with relevant international bodies. It sponsored various activities such as promotion of careers in the mathematical sciences, and the establishment of the Jones Medal. Unfortunately it was one of a number of committees disbanded 18 months ago, as part of a restructuring by the RSNZ Council. In 2011 the NZIMA played a role in re-establishment of the original grouping, by bringing representatives of the above societies (plus the NZ branch of ANZIAM, and Statistics NZ) at a meeting in June to consider the way forward, and possible future initiatives.

Mathematics of Planet Earth 2013: The year 2013 has been designated as one with a special focus on the “Mathematics of Planet Earth”, through an initiative being supported by the International Mathematical Union (IMU), the International Commission on Mathematical Instruction (ICMI), and the International Council of Industrial and Applied Mathematics (ICIAM).

Earth is a planet with dynamic processes in the mantle, oceans and atmosphere creating climate, causing natural disasters, and influencing fundamental aspects of life and life-supporting systems. In addition to these natural processes, humans have developed various complex systems including economic and financial systems, the World Wide Web, frameworks for resource management, transportation, and energy production and utilisation, health care delivery, and social organisations. Mathematics plays a key role in these and many other processes affecting Planet Earth, both as a fundamental discipline and as an essential component of multidisciplinary and interdisciplinary research.

Mathematics of Planet Earth 2013 (MPE 2013) will focus mathematical research in these fields, provide a platform to showcase the essential relevance of mathematics to planetary problems, coalesce activities currently dispersed among institutions, and create a context for mathematical and interdisciplinary developments to address a myriad of issues and meet global challenges in the future. For more details about MPE 2013, see <http://www.mpe2013.org>.



The NZ Mathematical Society and the NZIMA have both accepted invitations to be partners in this initiative, and in discussion about the best ways to contribute. As a minimum, they will organise a series of public lectures across New Zealand on this theme.

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, *NZIMAgas* and items for our schools' website, *MathsReach*.

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 2011 year

Income	Actual	Budget	Variance
CoRE Funding	\$ 203,888	\$ 203,888	\$ 0
Other income	0	0	0
Total Income	\$ 203,888	\$ 203,888	\$ 0
Expenditure			
Salaries			
Director & Principal Investigators	\$ 30,728	\$ 25,000	\$ (5,728)
Associate Investigators	14,769	15,000	231
Postdoctoral Fellows	35,564	13,750	(21,814)
Research/ Technical Assistants	0	0	0
Others	28,261	8,500	(19,761)
Total Salaries (a)	\$ 109,322	\$ 62,250	\$ (47,072)
Other Costs			
Project Costs	\$ 223,393	\$ 17,639	\$ (205,754)
Travel	66,065	7,500	(58,565)
Postgraduate Student Support	92,338	53,000	(39,338)
Indirect Costs: Overheads	123,745	62,250	(61,495)
Equipment depreciation	0	0	0
Rental - equipment	0	1,250	1,250
Subcontractors	0	0	0
Extraordinary expenditure	0	0	0
Total Other Costs (b)	\$ 505,542	\$ 141,638	\$ (363,904)
Total Expenditure	\$ 614,864	\$ 203,888	\$ (410,976)

Statement of Financial Position as at 31 December 2011

	Previous	Current	Nett
	Total	Year	Total
Funds committed to spend by February 2012	\$ 445,618	\$ (410,976)	\$ \$44,642

RESEARCH PUBLICATIONS

The following is a selection of publications in 2011 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

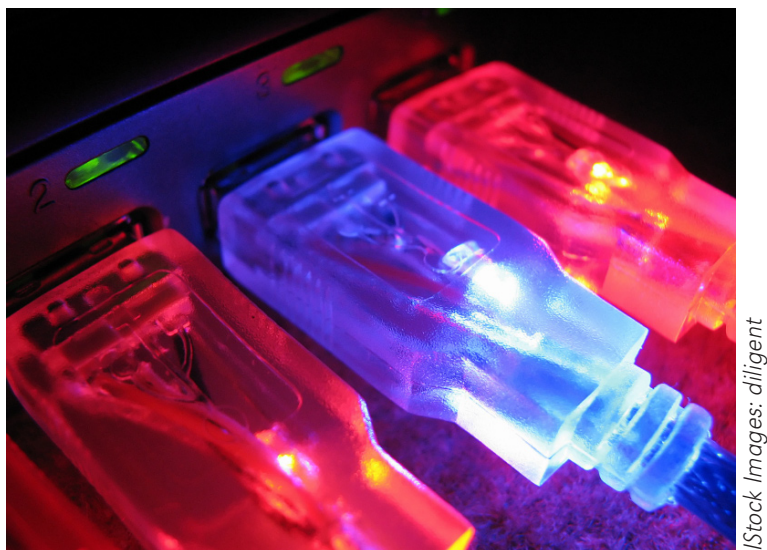
Abreu, Gabriel; Visser, Matt: Entropy bounds for uncollapsed rotating bodies. *J. High Energy Phys.* 2011, no. 3, 056, 14 pp.

Aldred, R.E.L.; Egawa, Yoshimi; Fujisawa, Jun; Ota, Katsuhiro; Saito, Akira: The existence of a 2-factor in $K_{1,n}$ -free graphs with large connectivity and large edge-connectivity. *J. Graph Theory* 68 (2011), no. 1, 77-89.

Aldred, R.E.L.; Plummer, Michael D.: Proximity thresholds for matching extension in planar and projective planar triangulations. *J. Graph Theory* 67 (2011), no. 1, 38-46.

An, Jianbei: Controlled blocks of the finite quasisimple groups for odd primes. *Adv. Math.* 227 (2011), no. 3, 1165-1194.

An, Jianbei; Eaton, Charles W.: Blocks with extraspecial defect groups of finite quasisimple groups. *J. Algebra* 328 (2011), 301-321.



An, Jianbei; Eaton, Charles W.: Nilpotent blocks of quasisimple groups for odd primes. *J. Reine Angew. Math.* 656 (2011), 131-177.

An, Jianbei; Hiss, Gerhard: Restricting unipotent characters in finite symplectic groups. *Comm. Algebra* 39 (2011), no. 3, 1104-1130.

Atkinson, M.D.; Ruskuc, N.; Smith, Rebecca: Substitution-closed pattern classes. *J. Combin. Theory Ser. A* 118 (2011), no. 2, 317-340.

Barcelo, Carlos; Liberati, Stefano; Sonogo, Sebastiano; Visser, Matt: Hawking-like radiation from evolving black holes and compact horizonless objects. *J. High Energy Phys.* 2011, no. 2, 003, 30 pp.

Barmpalias, George; Downey, Rod; Ng, Keng Meng: Jump inversions inside effectively closed sets and applications to randomness. *J. Symbolic Logic* 76 (2011), no. 2, 491-518.

Barmpalias, George; Nies, André: Upper bounds on ideals in the computably enumerable Turing degrees. *Ann. Pure Appl. Logic* 162 (2011), no. 6, 465-473.

Bonfert-Taylor, Petra; Martin, Gaven; Reid, Alan W.; Taylor, Edward C.: Teichmueller mappings, quasiconformal homogeneity, and non-amenable covers of Riemann surfaces. *Pure Appl. Math. Q.* 7 (2011), no. 2, Special Issue: In honor of Frederick W. Gehring, Part 2, 455-468.

Bray, J.N.; Conder, M.D.E.; Leedham-Green, C.R.; O'Brien, E.A.: Short presentations for alternating and symmetric groups. *Trans. Amer. Math. Soc.* 363 (2011), no. 6, 3277-3285.

Bui, H.-Q.; Laugesen, R.S.: Frequency-scale frames and the solution of the Mexican hat problem. *Constr. Approx.* 33 (2011), no. 2, 163-189.

Bui, H.-Q.; Laugesen, R.S.: Wavelets in Littlewood-Paley space, and Mexican hat completeness. *Appl. Comput. Harmon. Anal.* 30 (2011), no. 2, 204-213.

Butcher, John C.; Corless, Robert M.; Gonzalez-Vega, Laureano; Shakoory, Azar: Polynomial algebra for Birkhoff interpolants. *Numer. Algorithms* 56 (2011), no. 3, 319-347.

Calude, Cristian S.; Nies, André; Staiger, Ludwig; Stephan, Frank: Universal recursively enumerable sets of strings. *Theoret. Comput. Sci.* 412 (2011), no. 22, 2253-2261.

Catalano, Domenico A.; Conder, Marston D. E.; Du, Shao Fei; Kwon, Young Soo; Nedela, Roman; Wilson, Steve: Classification of regular embeddings of n -dimensional cubes. *J. Algebraic Combin.* 33 (2011), no. 2, 215-238.

Chun, Carolyn; Mayhew, Dillon; Oxley, James A: chain theorem for internally 4-connected binary matroids. *J. Combin. Theory Ser. B* 101 (2011), no. 3, 141-189.

Conder, Marston; Havas, George; Newman, M.F.: On one-relator quotients of the modular group, *Groups St Andrews 2009 in Bath (proceedings)*, vol. 1, London Math. Society Lecture Note Series, No. 387, Cambridge University Press, 2011, pp. 183-197.

Conder, Marston D.E.; Tucker, Thomas W.: The symmetric genus spectrum of finite groups. *Ars Math. Contemp.* 4 (2011), no. 2, 271-289.

Conder, Marston; Tucker, Thomas: Motion and distinguishing number two. *Ars Math. Contemp.* 4 (2011), no. 1, 63-72.

Cropp, Bethan; Visser, Matt: Any spacetime has a Bianchi type I spacetime as a limit. *Classical Quantum Gravity* 28 (2011), no. 5, 055007, 13 pp.

Day, Adam R.: Increasing the gap between descriptonal complexity and algorithmic probability. *Trans. Amer. Math. Soc.* 363 (2011), no. 10, 5577-5604.

Detinko, A.S.; Flannery, D.L.; O'Brien, E.A.: Algorithms for the Tits alternative and related problems. *J. Algebra* 344 (2011), 397-406.

Dietrich, Heiko; Moravec, Primoz: On the autocommutator subgroup and absolute centre of a group. *J. Algebra* 341 (2011), 150-157.

Ding, Yang; Grūnewald, Stefan; Humphries, Peter J.: On agreement forests. *J. Combin. Theory Ser. A* 118 (2011), no. 7, 2059-2065.

Downey, Rodney G.; Kach, Asher M.: Euclidean functions of computable Euclidean domains. *Notre Dame J. Form. Log.* 52 (2011), no. 2, 163-172.

Ehrgott, Matthias; Shao, Lizhen; Schöbel, Anita: An approximation algorithm for convex multi-objective programming problems. *J. Global Optim.* 50 (2011), no. 3, 397-416.

Faller, Beáta; Semple, Charles; Welsh, Dominic: Optimizing phylogenetic diversity with ecological constraints. *Ann. Comb.* 15 (2011), no. 2, 255-266.

Fitzgerald, Colm J.; Meylan, Michael H.: Generalized eigenfunction method for floating bodies. *J. Fluid Mech.* 667 (2011), 544-554.

Froyland, Gary; Murray, Rua; Stancevic, Ognjen: Spectral degeneracy and escape dynamics for intermittent maps with a hole. *Nonlinearity* 24 (2011), no. 9, 2435-2463.

Goldblatt, Robert: Quantifiers, propositions and identity. Admissible semantics for quantified modal and substructural logics. *Lecture Notes in Logic*, 38. Association for Symbolic Logic, Chicago, IL; Cambridge University Press, Cambridge, 2011. xiv+268 pp.

Gover, A. Rod; Hill, C. Denson; Nurowski, Pawel: Sharp version of the Goldberg-Sachs theorem. *Ann. Mat. Pura Appl.* (4) 190 (2011), no. 2, 295-340.

Greenberg, Noam: A random set which only computes strongly jump-traceable c.e. sets. *J. Symbolic Logic* 76 (2011), no. 2, 700-718.

Greenberg, Noam; Miller, Joseph S.: Diagonally non-recursive functions and effective Hausdorff dimension. *Bull. Lond. Math. Soc.* 43 (2011), no. 4, 636-654.

Greenberg, Noam; Montalbán, Antonio; Slaman, Theodore A.: The Slaman-Wehner theorem in higher recursion theory. *Proc. Amer. Math. Soc.* 139 (2011), no. 5, 1865-1869.

Greenberg, Noam; Nies, André: Benign cost functions and lowness properties. *J. Symbolic Logic* 76 (2011), no. 1, 289-312.

Guionnet, A.; Jones, V.; Shlyakhtenko, D.: A semi-finite algebra associated to a subfactor planar algebra. *J. Funct. Anal.* 261 (2011), no. 5, 1345-1360.

Gvozdeva, Tatiana; Slinko, Arkadii: Weighted and roughly weighted simple games. *Math. Social Sci.* 61 (2011), no. 1, 20-30.

Hall, Rhiannon; Mayhew, Dillon; van Zwam, Stefan H.M.: The excluded minors for near-regular matroids. *European J. Combin.* 32 (2011), no. 6, 802-830.

Hendtlass, Matthew; Schuster, Peter: Minima and best approximations in constructive analysis. *J. Log. Anal.* 3 (2011), Paper 5, 17 pp.

Hjorth, Greg; Nies, André: Borel structures and Borel theories. *J. Symbolic Logic* 76 (2011), no. 2, 461-476.

Jones, Vaughan F. R.; Penneys, David: The embedding theorem for finite depth subfactor planar algebras. *Quantum Topol.* 2 (2011), no. 3, 301–337.

Kalnins, Ernest G.; Kress, Jonathan M.; Miller, Willard, Jr.; Post, Sarah: Laplace-type equations as conformal superintegrable systems. *Adv. in Appl. Math.* 46 (2011), no. 1-4, 396-416.

Kalnins, Ernie G.; Kress, Jonathan M.; Miller, Willard, Jr.: A recurrence relation approach to higher order quantum superintegrability. *SIGMA Symmetry Integrability Geom. Methods Appl.* 7 (2011), Paper 031, 24 pp.

Kalnins, Ernie G.; Miller, Willard, Jr.; Post, Sarah: Two-variable Wilson polynomials and the generic superintegrable system on the 3-sphere. *SIGMA Symmetry Integrability Geom. Methods Appl.* 7 (2011), Paper 051, 26 pp.

Kiataramkul, Chanakarn; Wake, Graeme C.; Ben-Tal, Alona; Lenbury, Yongwimon: Optimal nutritional intake for fetal growth. *Math. Biosci. Eng.* 8 (2011), no. 3, 723-732.

Kucera, Antonin; Nies, André: Demuth randomness and computational complexity. *Ann. Pure Appl. Logic* 162 (2011), no. 7, 504-513.

Mayhew, Dillon; Newman, Mike; Welsh, Dominic; Whittle, Geoff: On the asymptotic proportion of connected matroids. *European J. Combin.* 32 (2011), no. 6, 882-890.

Mayhew, Dillon; Oporowski, Bogdan; Oxley, James; Whittle, Geoff: The excluded minors for the class of matroids that are binary or ternary. *European J. Combin.* 32 (2011), no. 6, 891-930.

- Mayhew, Dillon; Whittle, Geoff; van Zwam, Stefan H.M.: An obstacle to a decomposition theorem for near-regular matroids. *SIAM J. Discrete Math.* 25 (2011), no. 1, 271-279.
- McLachlan, R.I.; Sun, Y.; Tse, P.S.P.: Linear stability of partitioned Runge-Kutta methods. *SIAM J. Numer. Anal.* 49 (2011), no. 1, 232-263.
- McLachlan, Robert I.; Zhang, Xingyou: Asymptotic blowup profiles for modified Camassa-Holm equations. *SIAM J. Appl. Dyn. Syst.* 10 (2011), no. 2, 452-468.
- Modin, Klas; Perlmutter, Matthew; Marsland, Stephen; McLachlan, Robert: On Euler-Arnold equations and totally geodesic subgroups. *J. Geom. Phys.* 61 (2011), no. 8, 1446-1461.
- Neunhöffer, Max; Noeske, Felix; O'Brien, E.A.; Wilson, Robert A.: Orbit invariants and an application to the Baby Monster. *J. Algebra* 341 (2011), 297-305.
- Nordsletten, D.; McCormick, M.; Kilner, P.J.; Hunter, P.; Kay, D.; Smith, N.P.: Fluid-solid coupling for the investigation of diastolic and systolic human left ventricular function. *Int. J. Numer. Methods Biomed. Eng.* 27 (2011), no. 7, 1017-1039.
- Norris, S.E.; Were, C.J.; Richards, P.J.; Mallinson, G.D.: A Voronoi-based ALE solver for the calculation of incompressible flow on deforming unstructured meshes. *Internat. J. Numer. Methods Fluids* 65 (2011), no. 10, 1160-1179.
- O'Brien, E.A.; Willems, Wolfgang: On the automorphism group of a binary self-dual doubly even $[72,36,16]$ code. *IEEE Trans. Inform. Theory* 57 (2011), no. 7, 4445-4451.
- Oxley, James; Semple, Charles; Whittle, Geoff: Exposing 3-separations in 3-connected matroids. *Adv. in Appl. Math.* 47 (2011), no. 3, 463-508.
- Rea, William; Reale, Marco; Brown, Jennifer; Oxley, Les: Long memory or shifting means in geophysical time series? *Math. Comput. Simulation* 81 (2011), no. 7, 1441-1453.
- Sneddon, Jamie; Bonnington, Paul: A note on obstructions to clustered planarity. *Electron. J. Combin.* 18 (2011), no. 1, Research Paper 159, 6 pp.
- Suebcharoen, T.; Van Brunt, B.; Wake, G.C.: Asymmetric cell division in a size-structured growth model. *Differential Integral Equations* 24 (2011), no. 7-8, 787-799.

Tam, Bassy; Ehrgott, Matthias; Ryan, David; Zakeri, Golbon: A comparison of stochastic programming and bi-objective optimisation approaches to robust airline crew scheduling. *OR Spectrum* 33 (2011), no. 1, 49-75.

Tsai, Je-Chiang; Sneyd, James: Traveling waves in the buffered FitzHugh-Nagumo model. *SIAM J. Appl. Math.* 71 (2011), no. 5, 1606-1636.

van Brunt, B.; Wake, G.C.: A Mellin transform solution to a second-order pantograph equation with linear dispersion arising in a cell growth model. *European J. Appl. Math.* 22 (2011), no. 2, 151-168.

Wake, G.C.; Pleasants, A.B.; Vickers, M.H.; Sheppard, A.M.; Gluckman, P.D.: The application of a model of glucose and insulin dynamics to explain an observed effect of leptin administration in reversal of developmental programming. *Math. Biosci.* 229 (2011), no. 1, 109-114.

Walker, C.G.; Mackenzie, M.L.; Donovan, C.R.; O'Sullivan, M.J.: SALSA - a spatially adaptive local smoothing algorithm. *J. Stat. Comput. Simul.* 81 (2011), no. 2, 179-191.