NZ IMAges

ISSUE TWO

INSIDE

New Zealand Institute of Mathematics & its Applications

The maths of steel

Mathematics is at the heart of converting the black ironsands of Maioro, south of Auckland, to a variety of sheet steel products. Jenny Rankine explains.

Nick Depree is developing a mathematical model of the annealing furnace at New Zealand Steel's Glenbrook mill, but he has never been inside it.

This is because the 150m-long, brick-lined tunnel operates at up to 1,100 degrees celsius, 24 hours a day. "It would have to be shut down for two weeks to be cool enough to walk through", says Depree.

Rolling steel from a slab to a strip makes it hard and brittle. Annealing relieves the internal stresses and softens the steel. Without this process, we wouldn't have corrugated steel roofs, steel roof tiles or steel garage doors. About 10% of the mill's steel production passes through this furnace.

The New Zealand Steel annealing furnace at Glenbrook towers three stories above the mill floor. Photo: Nick Depree. Below: A rare view inside, showing the heating elements above the rollers and the thermocouples in the centre.

To ensure a continuous flow, each new coil of sheet steel is welded to the end of the last one, and feeds through the furnace at a fast walking pace. The furnace, built in 1968, is old by world standards; it uses up to 4.6MW of radiant electric heating in its first 100 metres. The rest is for cooling, so that the steel emerges at the right temperature for its dip in the coating pots.

Most modern annealing furnaces are shorter, vertical and gas-fired, enabling them to change temperature much faster than the NZS furnace.

The computers running the furnace currently use a static state model, which does not include details of the furnace construction or the recently installed induction heater and gas jet cooler.

This model is accurate for about half the furnace's operating time. When the furnace is changing temperature or speed for different steel thicknesses or widths, supervisors rely on scheduling rules built up from years of experience. They don't always work; the coil may emerge with wavy edges or be too soft. As a result, around 100 tonnes of steel has to be discarded or downgraded each year.

This is where Nick Depree and NZIMA principal researcher Professor James Sneyd come in. With engineers Mark Taylor and John Chen, Sneyd is supervising Depree's three-year PhD project to build a dynamic model that will predict furnace and strip temperatures and metal properties during these changing states.

The equations are impossible to do by hand, so ▶2

Welcome

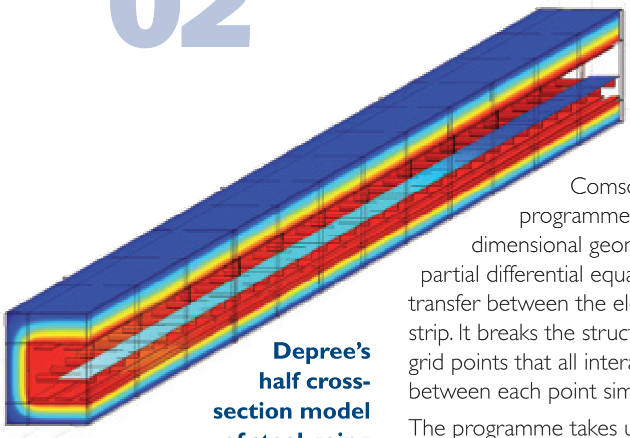
We hope you enjoy reading this second issue of *IMAges*, the colour bulletin of news and activities from the NZIMA.

This is part of the NZIMA's new programme of outreach, intended to open a window on a selection of mathematical activities across New Zealand, and make these accessible to a wider community.

It will be complemented by our new MathsReach initiative - a collection of resources for students and teachers, to show what lies beyond the school curriculum in mathematics. This will be launched in late February and developed over time.

Find out more from www.nzima.org.

Marston Conder and Vaughan Jones
Co-Directors



Depree's half cross-section model of steel going through the furnace.

◀ I Depree is using Comsol, a commercial modelling programme. "You build a three-dimensional geometry and plug into it all the partial differential equations that calculate the heat transfer between the elements, furnace and the strip. It breaks the structure into a mesh of 50,000 grid points that all interact, and solves the equations between each point simultaneously."

The programme takes up to four hours to solve the equations for the whole furnace. "I'm currently using a simplified half cross-section that can run in one and a half hours," says Depree. To be workable, the model has to be as simple as possible, while remaining accurate." Sneyd is advising on how to use maths to simplify the model. "It's not at all easy to do," he says.

Depree wants to get the model to within five degrees of the temperatures recorded by the furnace's 20 thermocouples. These wires of two different metals inside a metal pipe stick down through the furnace ceiling. The voltage difference where the wires connect measures the inside temperature; three pyrometers measure the radiation reflected off the steel.

"There is a lot of uncertainty in what these instruments are recording," says Depree. "I'm playing with heat transfer co-efficients as I fine-tune the model - conduction and radiation, which affect how the heat moves through the furnace and into the strip. Once I've got it to run acceptably, I'll need to run it many, many times to characterise different products and their dynamic properties." When it works, the model should cut steel wastage in half and reduce the furnace's power consumption by up to 10 percent.

NOTABLE MATHS PROBLEMS

RIEMANN HYPOTHESIS

The real part of any non-trivial zero of the Riemann zeta function is ½.

Simply: Some complex numbers - made up of ordinary numbers between 0 and 1, combined with a multiple of the square root of -1 - when fed into the zeta function produce the result zero. Do the infinity of such zeroes when graphed all lie on the same critical vertical line?

Discipline: Number theory. Hundreds of results in number theory now begin, "If the Riemann hypothesis is true, then..."

Originator: Georg Friedrich Bernhard Riemann, 1826-1866; German mathematician.

Incentive: $US1million, one of the seven Millennium Prize Problems of the USA-based Clay Mathematics Institute.

Attempted proofs: Supercomputer number-crunching has shown the hypothesis to be true for more than the first billion zeros. However, the hypothesis would be wrong if only one of the infinite results involved lies off the critical line. Several purported proofs have yet to be examined.

Is related to: Prime numbers. When the number of primes existing below a given number is plotted on a graph, it produces a smooth curve with small wiggles - the wiggles are the Riemann zeros. Riemann found that if the zeros do lie on the critical line then the maddeningly random distribution of prime numbers is predictable.

Unusual aspect: May be solved via similarities with quantum mechanics. French mathematician Alain Connes has constructed a quantum state space of infinite dimensions from the known prime numbers. In the first dimension, measurements are made with 2-adic geometry, which pulls together even numbers. The second dimension uses 3-adic geometry, the third 5-adic geometry and so on. Connes proved that the system has energy levels corresponding to all the Riemann zeros that lie on the vertical line, but he still has to prove that there are no zeros unaccounted for by these energy levels.

Could lead to: An efficient way of deciding whether a certain very large number is a prime. Mathematics based on the Riemann zeta function could predict the behaviour of chaotic quantum systems, such as the scattering of high energy levels in atoms and molecules, and the way in which sound and light waves bounce around.

NZIMA connection: Marcus du Sautoy, author of *The Music of the Primes*, which describes the hypothesis and its implications for a lay audience, will be visiting New Zealand as an NZIMA Maclaurin Fellow in February and March this year.

The study of mathematics is apt to commence in disappointment ... we are told that by its aid the stars are weighed and the billion of molecules in a drop of water are counted. Yet, like the ghost of Hamlet's father, this great science eludes the efforts of our mental weapons to grasp it. *Alfred North Whitehead, 1861-1947.*

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Jenny Rankine, Words and Pictures

Thinking around corners

By Jenny Rankine

It would be hard to find a less geeky mathematician than Vaughan Jones. The country's only Fields Medallist, the maths equivalent of the Nobel Prize, is famous for wearing a rugby jersey when he gave his plenary talk at the International Congress of Mathematicians that awarded the medal in Kyoto in 1990. And he kite boards the waves of San Francisco Bay in his spare time.

Jones is also famous for his informal and open style of working in an environment where competition can encourage mathematicians to keep ideas to themselves before they are published. Before winning the medal, Jones sent his new ideas to other mathematicians and encouraged their circulation. The medal citation says these letters became a rich source of ideas for many people.

Jones' discovery of the polynomial since named after him (an object that distinguishes between theoretical knots) was part of his development of an algebra that thinks around corners.

Anyone over 30 learnt algebra as a linear activity - A x B + C marching from left to right in a straight line to a conclusion. Jones thought laterally and imagined an algebra where A was upside down above B and C was off to the south-west. He has been working in the field of planar algebra ever since.

The field brings together ideas from operator theory, statistical mechanics and the more geometrical theory of knots and tangles. "It has created a structure for handling a lot of novel algebraic situations in a new way that is connected to physics and quantum field theory," he says.

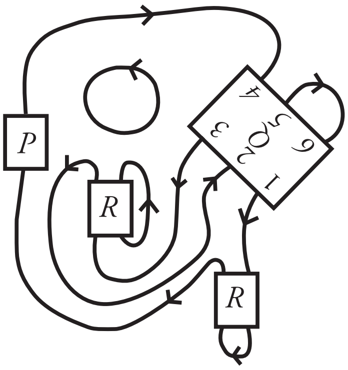
Physics is an old love for Jones, who started his PhD in the subject before switching to mathematics. "I've always done the kind of maths that's closely connected to physics." Planar algebra seems to be highly relevant to quantum computing, he says, although the role it will play is not yet clear.

Jones was born in Gisborne, went to school in Cambridge and Auckland and studied at the Universities of Auckland and Geneva. While he has been Professor of Mathematics at the University of California in Berkeley since 1985, he returns to New Zealand at least twice a year and has been a major stimulus for the growth of mathematics here.

He helped to found the New Zealand Mathematics Research Institute (NZMRI) in the early 1990s and is co-director of that as well as of the NZIMA. The NZMRI started an annual series of summer meetings in 1994, now sponsored by the NZIMA, bringing "the very best of world maths to mix with New Zealand mathematicians and students" at beautiful New Zealand beachside locations.

"They went from being rather primitive affairs to much more well-known and now we're turning people away," he says. "They've been a staggering success; you'd have real difficulty getting some of those people together anywhere else in the world." The Fields Medal was very useful to help get the meetings started, he says. He has been to every meeting, gaining a good overview of our mathematical expertise.

Maths in New Zealand "looks pretty healthy; we have some extremely good mathematicians here". New Zealand shines in fields such as numerical analysis, "providing numerical solutions for just about anything"; computer solutions; analysis; group theory; logic and computational complexity; mathematical biology and mathematical physics. "We have really world class leaders in those fields in New Zealand, constantly being invited to international conferences."



A labelled planar tangle

"A mathematician is a machine for turning coffee into theorems."
Paul Erdős
1913 - 1996

Supporting talented maths students

Simon Marshall, New Zealand's only gold medallist at the International Mathematical Olympiad (IMO), was introduced to the Olympiad in third form in 1998. Jenny Rankine talked with him.

A teacher gave Marshall the questions distributed each September by the New Zealand Mathematical Olympiad Committee (NZMOC). The top 24 respondents are invited to a week-long live-in Mathematical Training Camp each January.

He didn't get into the camp that year, but he took the NZMOC Certificate course through the University of Auckland, along with his Onslow College subjects, and was chosen for the 2000 camp.

"It was an amazing experience; I'd never had so much maths put through me. It was good socialising with quick-witted people who really loved maths. I didn't get selected for the IMO team; but that year I did IMO-level maths problems almost constantly and finally started to get somewhere."

At the 2001 camp he was chosen for the IMO team competing in Washington DC in July, his first overseas trip. He and the other Wellington team member met weekly with a Victoria University lecturer.

The 2004 New Zealand IMO team after the closing ceremony in Athens. Left to right: Eve Waddington, Jethro van Ekeren (bronze), Simon Marshall, Heather Macbeth (bronze), Eric Kang, James Liley, James McKaskill. Absent: Team leader Arkadii Slinko.

The annual IMO competition started in 1959 and involves the top high school maths students from 90 countries. They send teams of up to six people who compete as individuals. New Zealand has the best female representation and the last three teams have all included Maori members. Competitors answer six problems, each worth seven points, in two four-hour exams. Of the 500 or so students, about half get a medal - 40 gold, 80 silver and over 100 bronze.

"I got 24 out of 42, a silver medal. It's one thing to be measured against everyone in the country, but to be measured against everyone else in the world and come out pretty favourably - I thought maybe I've got some talent." Team member Stephen Merriman also won a bronze.

"Camp was quite different the next year. There was an assumption that I was going to go back and get a gold medal, and that's what I wanted."

The pressure was on at his second Olympiad in Glasgow in 2002; the stress still resonates in his voice. "When we compared notes after the first day I realised I'd misinterpreted a question and would get no points for it. I was so despondent I said I'd eat a whole jar of jam if I got the medal - and I did."

Marshall scored 29 and the New Zealand team gained its second-highest score and highest ever ranking of 35.

The University of Auckland and the NZIMA created a scholarship especially for Marshall in recognition of his achievement. "The gold medal made me take my mathematical abilities a lot more seriously and push myself harder at university."

In 2004 and 2005 he was IMO deputy team leader. "I travelled with them to Athens and Mexico, making them feel confident, answering their questions. I was like an expectant father waiting for the results - you share their nervousness and you feel really happy when they've done well."

Marshall's straight A+ results in his BSc and the papers he'd submitted to journals as an undergraduate gained him entry to all of the 11 universities he applied to for postgraduate study. He is intrigued by the problems about equations and integers he is studying in number theory at Princeton. "You might want to find the solutions where integers are prime numbers. Some questions are so simple to ask but very difficult to solve." He looks forward to contributing to maths in New Zealand after his PhD.

The NZIMA has supported the NZMOC directly since 2003. NZIMA Co-director Marston Conder describes it as "an impressive organisation, with a pyramid of training, mentoring and selection involving hundreds of students and teachers before the chosen team competes at the IMO itself."

2002 IMO questions

Question A3

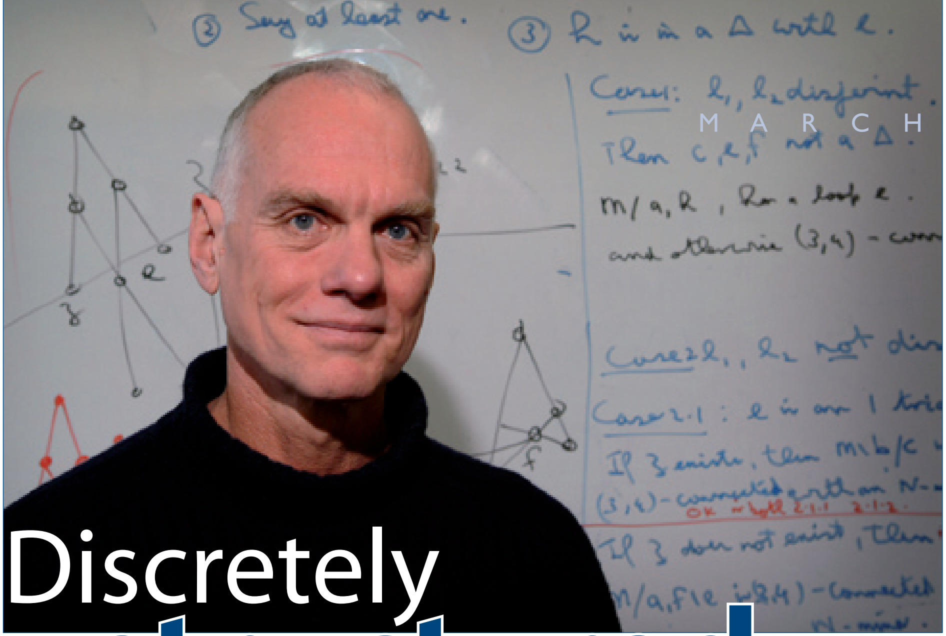
Find all pairs of integers $m > 2$, $n > 2$ such that there are infinitely many positive integers k for which $(k^n + k^2 - 1)$ divides $(k^m + k - 1)$.

Question B2

Find all real-valued functions f on the reals such that $(f(x) + f(y))\,(f(u) + f(v)) = f(xu - yv) + f(xv + yu)$ for all x, y, u, v.

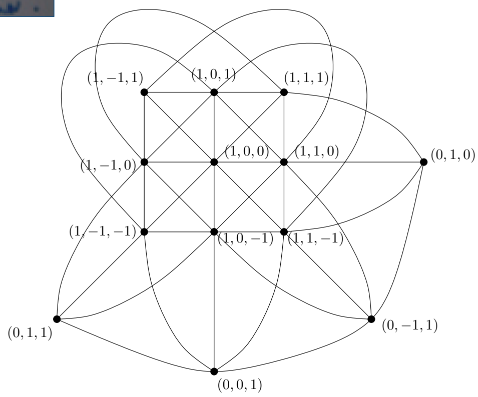
Question B3

$n > 2$ circles of radius 1 are drawn in the plane so that no line meets more than two of the circles. Their centres are $O_1, O_2, \dots, O_n$. Show that $\sum_{i<j} 1/O_iO_j \le (n-1)\pi/4$.



Discretely structured

Geoff Whittle.
Photo: Martin Stewart.
Below: A basic matroid.



Every year, the NZIMA awards a Maclaurin Fellowship to enable a New Zealand mathematician to take time out for full-time research. The 2006 recipient was Geoff Whittle, a Professor of Mathematics at Victoria University. Anna Meyer spoke with him.

The mathematics that was successful over the last 300 years is what physicists used for modelling things like movement in space and time, or effects under a gravitational field, says Professor Whittle. "These are situations where you have a continuous change."

With the development of computers, which operate using only discrete numbers - those that jump from one to the next with no graduations in between - a completely new type of mathematics was needed.

Discrete number systems are all around us - we are all familiar with the 12 hour clock, for example, where 7 hours after 7 o'clock is 2 o'clock, so that 7+7=2. The field of discrete mathematics is now a major area of interest for mathematicians.

Professor Whittle's research concentrates on matroid theory, a part of discrete mathematics that deals with the sometimes highly unusual geometric structures that can be constructed from sets of discrete numbers.

Familiar Euclidean geometry involves drawing shapes based on the infinite number of points that lie on a line of continuous numbers. Examples include a sphere or a cube, or the spatial positions on a map, which have a smooth, continuous connection between points.

Geometry using discrete numbers, however, is a little different; structures drawn from them have only a finite number of points. The points 'jump' from one to the next, and anything in between simply does not exist. "It's not the familiar world of geometry," said Professor Whittle. "But it's a world that makes a lot of sense to a computer."

Matroids are a specific type of discrete geometry. The illustration is an example of a basic matroid. The points represent co-ordinates specified by numbers from a discrete number set. These are just like the x,y,z points on a continuous graph, or points of latitude and longitude on a map, except there are only a finite number of points in a matroid. The lines show the relationships between each point, such as whether several points lie on a straight line.

For any particular discrete number system, an enormous number of different matroids can be constructed. "You can decide to make points with only three co-ordinates, or even ones with 10 co-ordinates," said Professor Whittle. "The ones we can draw are the ones that exist in two and three dimensions, but they could exist in a million dimensions. Tragically, we can't visualise those ones. That's where the mathematics becomes important, as a way of rigorously testing that you're not kidding yourself!"

Professor Whittle is investigating the properties of different matroids. He is trying to answer a key question about infinite sets. An infinite number of matroids can be obtained from each discrete number system. However, like a set of Russian dolls, some may be contained in others. It seems that if we avoid having matroids contained in others, then it is only possible to construct a finite set of matroids from a given discrete number system. If this could be proven, it would make matroids much simpler and easier to work with.

"Seeing that something is finite, when you would have expected it to be infinite, is very, very powerful," he said. "I spend my time dreaming about this sort of stuff, much to my wife's annoyance."

Professor Whittle describes himself as "an old-fashioned type of pure mathematician," preferring the intrinsic interest value of his work to any potential uses. "Personally, I don't care about whether the stuff I do has any use or not – although a lot of it does turn out to be useful," he said. "I view mathematics as being like music or poetry."

"If you were talking to a musician, you wouldn't dream of asking for applications, but somehow or other, mathematics has to sell itself. Because it is so useful, people think that it only exists for its use, but actually that's not true. The development of mathematics is one of the rich streams of intellectual history."

Amir Joshan and Andy Philpott. Photo: Godfrey Boehnke.

Revenue management

By Jenny Rankine

You're enduring the Auckland to Los Angeles leg of your long-awaited OE, looking forward to landing in London in 20 hours. Your flights were booked months ago at the lowest rate you could find. The passenger on your left got her ticket yesterday for a conference in San Francisco tomorrow and is working frantically on her presentation. The guy on the right bought his single-leg ticket for a lower price than yours in an airpoints promotion that started a month after you'd paid for your seat.

You don't spare a thought for the airline staff who have to juggle such unconnected and competing demands. NZIMA programme co-director Professor Andy Philpott, PhD student Amir Joshan and honours student Michael Frankovich, however, do. They are developing more sophisticated revenue management models for airlines. This fast-growing area of mathematics was kick-started in the 1980s with the arrival of the first cut-price airline in the USA. It now encompasses hotel, rental car, sports-event seating and electricity markets.

Airline revenue management models are based on the fact that different customers are willing to pay different amounts for the same seat; the models aim to extract greater income from airplane seating by differentiating between these customers.

"It's difficult mathematics because customers don't show up all at once", says Philpott. "The first complication is deciding how many seats should be reserved for possible high fare customers who haven't booked. The second complication is that most itineraries consist of sequences of flights. The airline has to decide whether it is better to accept a single-leg customer or to keep seats free for passengers wanting a longer route."

"The third complication is competition. These decisions are all affected by how other airlines are pricing their seats." As part of his PhD thesis, Amir Joshan is developing a preliminary model that accounts for competition between airlines, using data from Air New Zealand.

"Most airlines use commercial revenue management systems, developed by USA software companies such as Sabre and PROS," says Philpott. They are generally based on heuristics - rules of thumb that perform well in practice but are not necessarily optimal.

Philpott is also working with Garrett Van Ryzin at Columbia University on improving computation methods for solving network revenue management problems. Frankovich is experimenting with different networks, classes of arrival process, during high and low use of an airline. Philpott will meet Van Ryzin in Veinna in August to complete the project.

"We're using the theory of multi-stage stochastic linear programming to develop policies that can be proved to be within a certain tolerance of optimal, but we're still a fair distance from the real picture," says Philpott.

"We sample from an idealised model of arrivals that is based on historical airline data. We develop a policy about whether or not to accept a customer requesting a certain type of seat, and then simulate it in comparison with the deterministic linear programming policies that are typically used in practice. In preliminary experiments our policies are doing better."

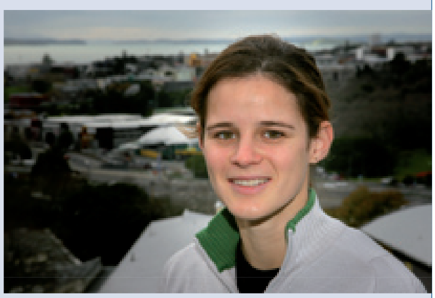
$$\text{maximize } r^T y \text{ subject to } Ay \leq x,\ y \leq E[D],\ y \geq 0.$$

Postgraduate scholarships

NZIMA awarded three new Postgraduate Scholarships in 2006. These went to Dion O'Neale at Massey University, and Tiangang Cui and Kim Noakes at the University of Auckland.

Pelvic floor modelling

Masters' student **Kim Noakes** is working to create anatomically accurate and patient-specific computational models of the male and female pelvic floor and anal canal regions. Ultimately this will aid the diagnosis of pelvic floor disorders and enable virtual planning of corrective surgeries. These disorders seriously reduce the quality of life of up to 15 percent of the population. Noakes has created one patient model, and hopes to use it to perform a functional analysis of a muscle contraction. The same MRI patient has undergone a manometry study to record the pressures in the anal canal exerted by their surrounding muscles. Noakes will try to match this mathematically on the computer model of the patient.



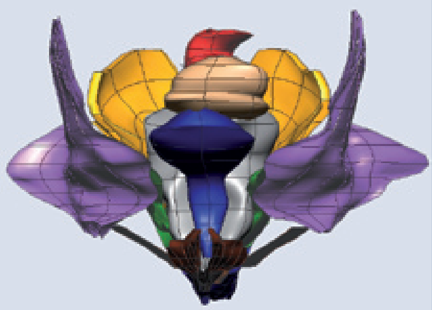
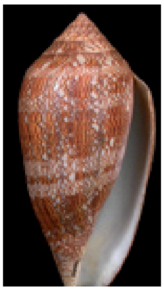


Photo: Godfrey Boehnke. The pelvic floor model is shown from the front.

Varied applications of cell grids

Most non-mathematicians would be struggling to make meaningful connections between forest fires, earthquakes and urban gang recruitment. Not so William Newman. He spoke with Jenny Rankine.



Newman, a professor from the University of California at Los Angeles, is an NZIMA-sponsored visiting expert who lectured on cellular automata and chaos theory in Auckland and in Christchurch in July, and renewed connections with New Zealand mathematicians.

Cellular automata arose from mathematical models of biological systems and descriptions of natural and engineering networks. It consists of a large, regular grid of cells, each in one of several states, modelled over time. Its roots are in formulae for object permutations and combinations in systems, fractal geometry and directed graphs.

To apply the discipline to forest fires, a mathematician assumes tree seeds are planted randomly in an area at a given time. New seeds will not take root where another tree is growing, leading to patterned clusters of mature trees. To stimulate fires, the mathematician imagines a random hand dropping matches or lightning bolts.

"The accumulation of flammable material on forest floor sets up clusters of trees for calamitous fires," says Newman. "In this imaginary landscape a cluster will be destroyed if lightning hits a tree. Eventually, equilibrium emerges between clusters of trees and fires. The model can suggest the best time and place for limited controlled fires to eliminate underbrush so that any accidental fires are self-limiting." This work has been of great interest to the US Forest Service.

Cellular automata are also applied to the distribution and size of earthquakes, which release accumulated stress from deformations in the earth's crust. Newman says that many years ago, a UK meteorologist became interested in the use of maths to address conflict. "He gathered data on gangs from Chicago in the 1920s and in occupied Manchuria in the early 1940s. The stats plots exactly matched what we see in forest fires and the statistical distribution followed the power law, for example, describing how much more common smaller gangs were than those twice as big."

"Planting a tree is equivalent to recruiting a gang member. A forest fire is equivalent to the break up of a gang - the common feature is geometry, their relationship in space." Newman's research has led him to see gangs as a universal response to urban social problems, unrelated to any particular ethnicity or time.

"If our model has any sense, the place we can help prevent recruitment is in areas with very few gang members. We won't get very far where they are entrenched. Of course," he qualifies, "this is an extrapolation with no scientific basis as yet."

During his visit, Newman renewed his friendship with Professor James Sneyd at the University of Auckland, who was involved with the 2003 NZIMA programme on modelling cellular function. They are both now working on the mathematics of brain tumours and Newman believes cellular automata may provide a useful approach.

William Newman. Photo: Godfrey Boehnke.

"Cells don't just sit there - they reproduce, die and multiply. But maths methods about the behaviour of fluids are based on the notion that molecules of water are neither created nor destroyed. Cellular automata could provide a way to account for this."

Postgraduate scholarship

Geothermal modelling

PhD student **Tiangang Cui** is exploring statistical techniques for quantifying the parameters and modelling errors associated with numerical models of geothermal fields.

These models simulate multi-phase flow - the simultaneous movement of gases, liquids and solids - by solving a large system of non-linear partial differential equations (PDEs). PDEs relate an unknown function of several independent variables and its partial derivatives for those variables. As well as the flow of fluids, PDEs are used to formulate and solve problems such as the propagation of sound or heat, electro-dynamics and elasticity.

Geothermal field models use finite volume methods, which represent and evaluate PDEs as algebraic equations. Values are calculated at discrete places on a meshed geometry; finite volume refers to the small volume surrounding each node point on a mesh.

Cui is researching sample-based Bayesian inference to calibrate the model. This method uses observations from the geothermal fields to calculate the probability that the model may be accurate.

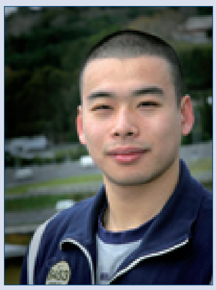
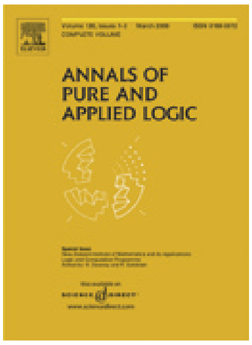


Photo: Godfrey Boehnke.

Journal special issue

A SPECIAL ISSUE of the journal *Annals of Pure and Applied Logic* has been published by Elsevier, as part of the NZIMA programme in Logic and Computation. This appeared in 2006 as Volume 138 of the journal, with guest editors Rod Downey and Rob Goldblatt from Victoria University of Wellington.



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MATHEMATICAL EVENTS

15 March 2007, University of Auckland
Music of the Primes, Public lecture by Professor Marcus du Sautoy

16 March, Victoria University of Wellington
Why flatland is a great place to do algebra, Public lecture by Professor Vaughan Jones

16 - 20 April, Hanmer Springs
NZIMA Programme Workshop on Modelling Invasive Species and Weed Impact www.math.canterbury.ac.nz/bio/NZIMA/

4 - 6 July, Christchurch
2007 NZ Statistical Association Conference, nzsa2007@gmail.com.

25 - 28 September, Auckland
New Zealand Association of Mathematics Teachers (NZAMT) 10th Biennial Conference, www.cce.auckland.ac.nz/conferences/index.cfm?S=CCE_NZAMTC

3 - 7 December, Dunedin (to be confirmed)
32nd ACCMCC (Australasian Conference on Combinatorial Mathematics and Combinatorial Computing), mike@cs.otago.ac.nz

12 - 15 December, Victoria University of Wellington
1st Joint Meeting of the American and New Zealand Mathematical Societies, www.mcs.vuw.ac.nz/~mathmeet/amsnzms2007/

Awards and honours

PROFESSOR ANDY PHILPOTT was presented with the 2006 Daellenbach Prize in November for his major contributions to the theory and practice of operations research in New Zealand and internationally. Philpott is Co-Director of the NZIMA programme on Mathematical Models for Optimizing Transportation Services, and Head of the Department of Engineering Science at the University of Auckland.

The three-year prize was established by the Operations Research Society of New Zealand (ORSNZ) to honour the contributions of Emeritus Professor Hans Daellenbach and reward outstanding examples of management science and operations research. The citation acknowledged Philpott's publications in prestigious international optimization and operations research journals and his many invitations to present at major international conferences.

ORSNZ President, Professor David Ryan, left, with Professor Philpott at the Royal Society of New Zealand awards night. Both are NZIMA Board Members. Photo: Andrew Mason.

ROD DOWNEY, the first NZIMA Maclaurin Fellow, was an invited speaker at the International Congress of Mathematics, ICM2006, held in August in Madrid, Spain. This is the first time ever that a New Zealand based-mathematician has been invited to speak at the ICM.

PETER HUNTER, member of the NZIMA Governing Board and Director of the Bioengineering Institute, and Jerry Marsden, member of the NZIMA International Scientific Advisory Board, have been elected as Fellows of the Royal Society of London.

CATHERINE McCARTIN, who was involved in the NZIMA's Logic and Computation programme, has won the Royal Society of New Zealand's Hatherton Award for 2006, for the best scientific paper by a PhD student at any New Zealand university.

ALASTAIR SCOTT, member of the NZIMA Board, has won the Waksberg Award for 2006 from the American Statistical Association and the Statistical Society of Canada, for his work on survey sampling.

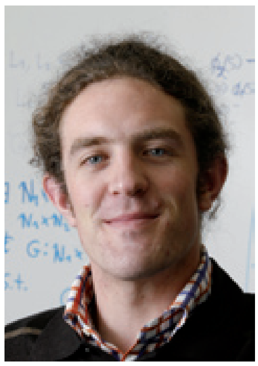
Postgraduate scholarship

Applications of geometric numerical integration

PhD candidate **Dion O'Neale** is studying the application of geometric numerical integration to systems of Hamiltonian differential equations. Geometric numerical integrators are computational methods for finding approximate solutions to differential equations. They differ from traditional numerical integration methods in that they attempt to preserve the equations' geometric properties, which often arise from physical laws such as conservation of energy.

One particular application is to coupled-spin systems. This type of Hamiltonian system is widely used in physics for modeling strongly correlated systems. One important feature of Hamiltonian systems is the existence of periodic solutions. When such a system is discretised by applying a numerical integrator to it, as many as possible of these periodic solutions should be preserved. For the discretised system, the analogue of a periodic solution is an invariant circle.

O'Neale is comparing the set of periodic orbits of a Hamiltonian system with the set of invariant circles obtained by discretising the system with a type of geometric numerical integrator. He aims to identify a set of periodic orbits that is always preserved by the integrator.



Dion O'Neale. Photo: Graeme Brown