CARMA Past, Present and Future for VC Visit 18-10-2013 (and CARMA Annual Retreat)

Jonathan M. Borwein FRSC FAA FBAS FAAAS

Laureate Professor & Director of CARMA, University of Newcastle

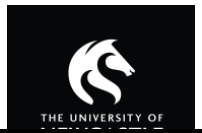
URL: http://carma.newcastle.edu.au/jon/vc-visit13.pdf

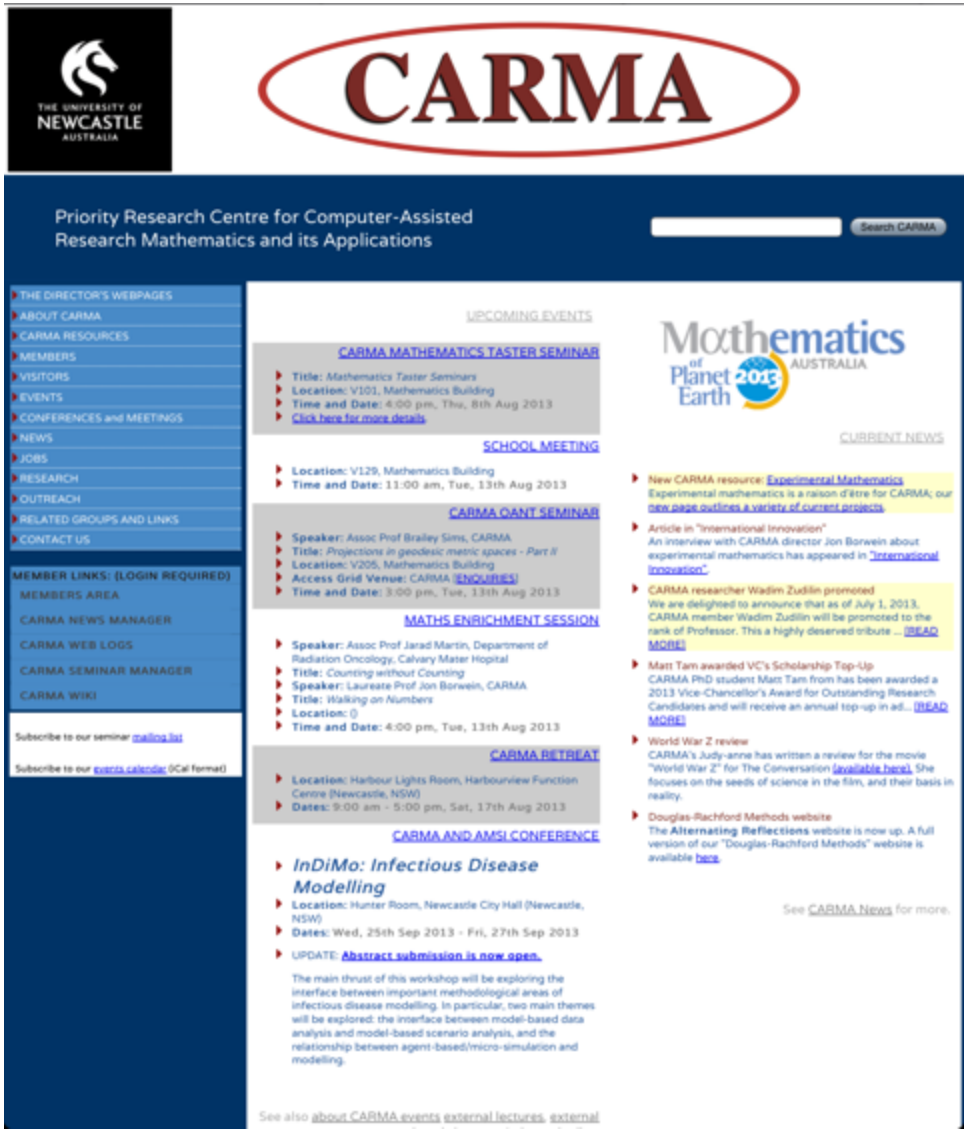
NEWS: http://carma.newcastle.edu.au/carmanews.shtml

Priority Research Centre for

Computer Assisted Research Mathematics and its Applications

Revised: October 16, 2013



Please:

1. Bookmark this Home page
2. Regularly monitor Events
   - and make sure they are advertised
3. Report Issues to
   - David Allingham and Roslyn Hickson
4. Post News Items

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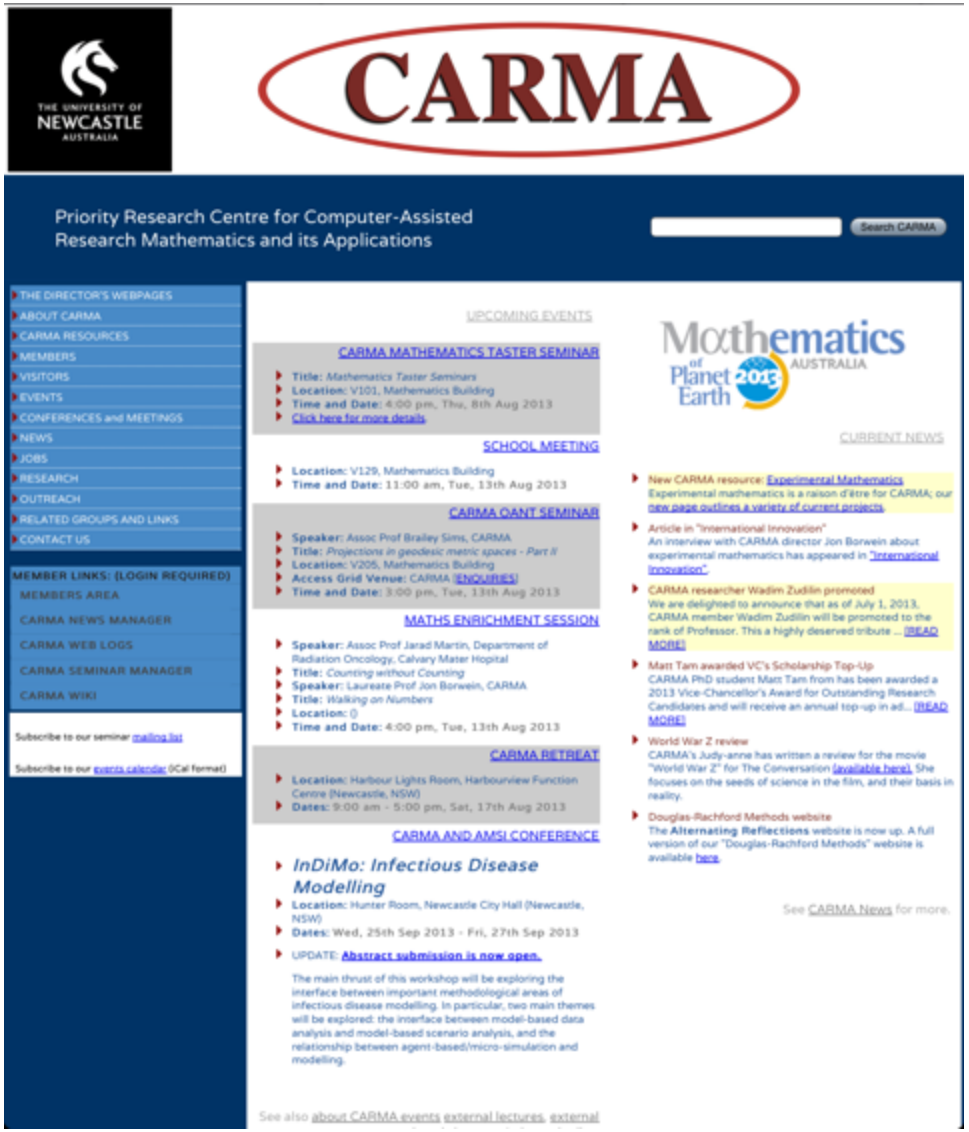

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Contents

Following introductions, we will *sample*

CARMA

CARMA's Leadership

... diversity

CARMA STEERING COMMITTEE

Willis (deputy) Meylan (events) Hickson (web) Elder (pubs) Osborn (ed) Sims (memory)

External Advisory Committee

Joseph (IBM, Chair) Bailey (LBNL/UCD) Guttmann (Melbourne Uni)

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- Apologies: Joseph, Miller, Sims, Turner, Zudilin, ...

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CARMA's Support Staff

... commitment

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Andrew Danson (`AGR')

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  - with unfailing good grace, imagination and energy

– **AGR** is a misonmer: it is really an **ACE**

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CARMA

I. Computer Assisted Research Mathematics: what it is?

Experimental mathematics is the use of a computer to run computations—sometimes no more than trial-and-error tests—to look for patterns, to identify particular numbers and sequences, to gather evidence in support of specific mathematical assertions that may themselves arise by computational means, including search.

Like contemporary chemists — and before them the alchemists of old—who mix various substances together in a crucible and heat them to a high temperature to see what happens, today's experimental mathematicians put a hopefully potent mix of numbers, formulas, and algorithms into a computer in the hope that something of interest emerges. (JMB-Devlin, 2008, p. 1)

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Experimental Mathematics: Integer Relation Methods

Secure Knowledge without Proof. Given real numbers $\beta, \alpha_1, \alpha_2, \ldots, \alpha_n$ Ferguson's integer relation method (PSLQ), finds a nontrivial linear relation of the form

$$a_0\beta + a_1\alpha_1 + a_2\alpha_2 + \cdots + a_n\alpha_n = 0, \qquad (1)$$

where a_i are integers—if one exists and provides an exclusion bound otherwise.

- If $a_0 \neq 0$ then (1) assures β is in rational vector space generated by $\{\alpha_1, \alpha_2, \ldots, \alpha_n\}$.
- $\beta = 1, \alpha_i = \alpha^i$ means α is algebraic of degree n
- **2000** *Computing in Science & Engineering*: PSLQ one of top 10 algorithms of 20th century

(**2001** CISE article on *Grand Challenges* (JB-PB))

PROFILE: HELAMAN FERGUSON

Carving His Own Unique Niche, In Symbols and Stone

By refusing to choose between mathematics and art, a self-described "misfit" has found the place where parallel careers meet

CMS D. Borwein Prize

Madelung constant (**2013** book)

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Top Ten Algorithms: all but one well used in CARMA

Algorithms for the Ages

"Great algorithms are the poetry of computation," says Francis Sullivan of the Institute for Defense Analyses' Center for Computing Sciences in Bowie, Maryland. He and Jack Dongarra of the University of Tennessee and Oak Ridge National Laboratory have put together a sampling that might have made Robert Frost beam with pride--had the poet been a computer jock. Their list of 10 algorithms having "the greatest influence on the development and practice of science and engineering in the 20th century" appears in the January/February issue of Computing in Science & Engineering. If you use a computer, some of these algorithms are no doubt crunching your data as you read this. The drum roll, please:

1. **1946: The Metropolis Algorithm for Monte Carlo.** Through the use of random processes, this algorithm offers an efficient way to stumble toward answers to problems that are too complicated to solve exactly.
2. **1947: Simplex Method for Linear Programming.** An elegant solution to a common problem in planning and decision-making.
3. **1950: Krylov Subspace Iteration Method.** A technique for rapidly solving the linear equations that abound in scientific computation.
4. **1951: The Decompositional Approach to Matrix Computations.** A suite of techniques for numerical linear algebra.
5. **1957: The Fortran Optimizing Compiler.** Turns high-level code into efficient computer-readable code.
6. **1959: QR Algorithm for Computing Eigenvalues.** Another crucial matrix operation made swift and practical.
7. **1962: Quicksort Algorithms for Sorting.** For the efficient handling of large databases.
8. **1965: Fast Fourier Transform.** Perhaps the most ubiquitous algorithm in use today, it breaks down waveforms (like sound) into periodic components.
9. **1977: Integer Relation Detection.** A fast method for spotting simple equations satisfied by collections of seemingly unrelated numbers.
10. **1987: Fast Multipole Method.** A breakthrough in dealing with the complexity of n-body calculations, applied in problems ranging from celestial mechanics to protein folding.

From *Random Samples*, Science page 799, February 4, 2000.

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Experimental Mathematics: PSLQ is core to CARMA

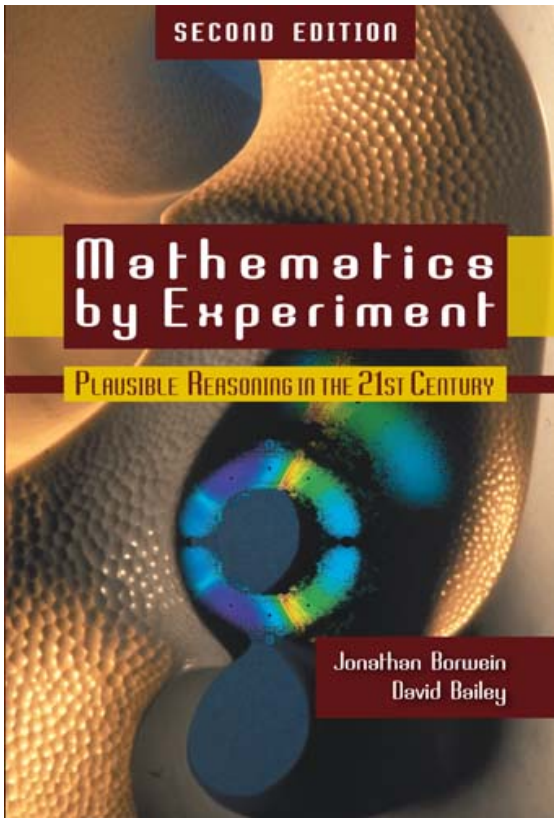
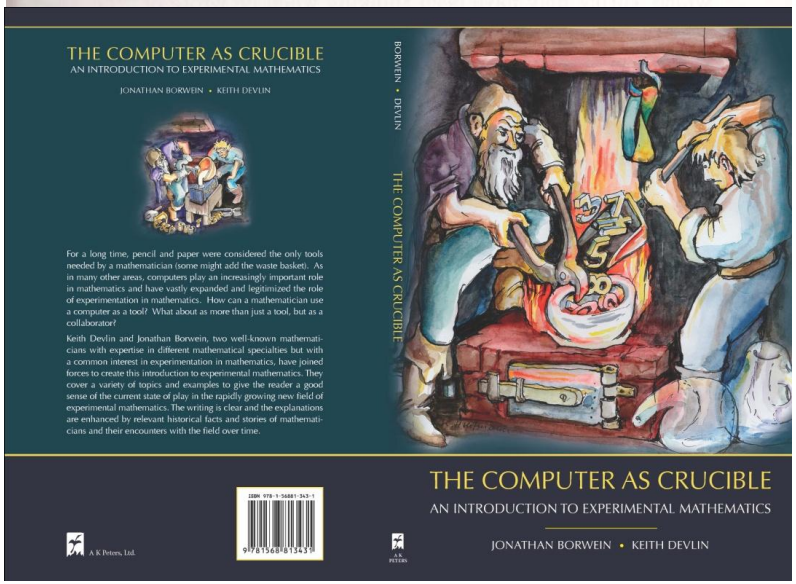
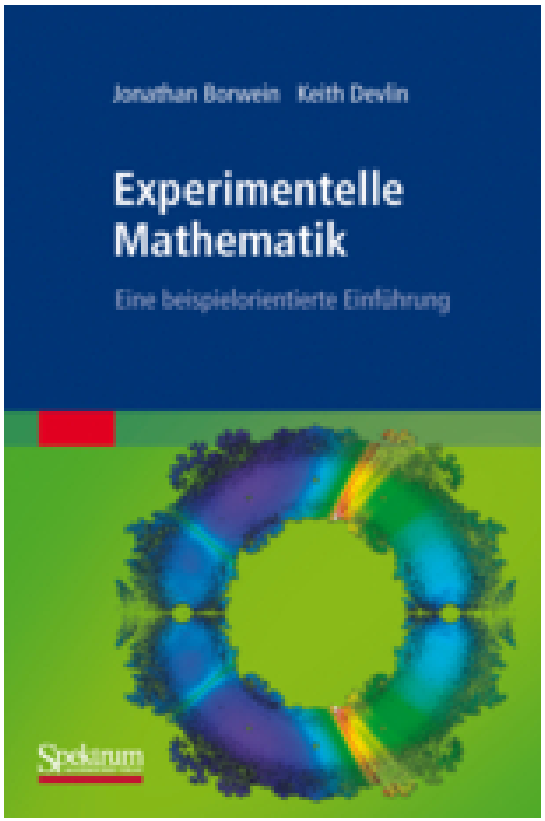


Figure 6.3. Three images quantized at quality 50 (L), 48 (C) and 75 (R). Courtesy of Mason Macklem.





Experimental Mathematics (2004-08, 2009, 2010)

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Notices of AMS 2011: ... and hundreds of online re-publications

Exploratory Experimentation and Computation

David H. Bailey and Jonathan M. Borwein

The authors' thesis—once controversial, but now a commonplace—is that computers can be a useful, even essential, aid to mathematical research.

—Jeff Shallit

Jeff Shallit wrote this in his recent review (MR2427663) of [10]. As we hope to make clear, Shallit was entirely right in that many, if not most, research mathematicians now use the computer in a variety of ways to draw pictures, inspect numerical data, manipulate expressions symbolically, and run simulations. However, it seems to us that there has not yet been substantial and intellectually rigorous progress in the way mathematics is presented in research papers, textbooks, and classroom instruction or in how the mathematical discovery process is organized.

Mathematicians Are Humans

We share with George Pólya (1887–1985) the view [25, vol. 2, p. 128] that, while learned,

> intuition comes to us much earlier and with much less outside influence than formal arguments.

Pólya went on to reaffirm, nonetheless, that proof should certainly be taught in school.

We turn to observations, many of which have been fleshed out in coauthored books such as *Mathematics by Experiment* [10] and *Experimental Mathematics in Action* [3], in which we have noted the changing nature of mathematical knowledge and in consequence ask questions such as "How do we teach what and why to students?", "How do we come to believe and trust pieces of mathematics?", and "Why do we wish to prove things?" An answer to the last question is "That depends." Sometimes we wish insight and sometimes, especially with subsidiary results, we are more than happy with a certificate. The computer has significant capacities to assist with both.

Smail [27, p. 113] writes:

> the large human brain evolved over the past 1.7 million years to allow individuals to negotiate the growing complexities posed by human social living.

As a result, humans find various modes of argument more palatable than others and are more prone to make certain kinds of errors than others. Likewise, the well-known evolutionary psychologist Steve Pinker observes that language [24, p. 83] is founded on

> the ethereal notions of space, time, causation, possession, and goals that appear to make up a language of thought.

This remains so within mathematics. The computer offers scaffolding both to enhance mathematical reasoning, as with the recent computation connected to the Lie group E_8 (see http://www.aimath.org/E8/computerdetails.html), and to restrain mathematical error.

Experimental Mathodology

Justice Potter Stewart's famous 1964 comment, "I know it when I see it," is the quote with which

David H. Bailey is Chief Technologist of the Computational Research Department at Lawrence Berkeley National Laboratory. His email is dhbailey@lbl.gov. *This work was supported by the director, Office of Computational and Technology Research, Division of Mathematical, Information, and Computational Sciences of the U.S. Department of Energy, under contract number DE-AC02-05CH11231.*

Jonathan M. Borwein is Laureate Professor at the Centre for Computer Assisted Research Mathematics and its Applications (CARMA) at the University of Newcastle, Australia. His email address is jonathan.borwein@newcastle.edu.au.

The Computer as Crucible [13] starts. A bit less informally, by *experimental mathematics* we intend [10]:

(a) gaining insight and *intuition*;
(b) *visualizing* math principles;
(c) *discovering* new relationships;
(d) *testing* and especially *falsifying* conjectures;
(e) *exploring* a possible result to see if it *merits* formal proof;
(f) *suggesting* approaches for formal proof;
(g) *computing* replacing lengthy hand derivations;
(h) *confirming* analytically derived results.

Of these items, (a) through (e) play a central role, and (f) also plays a significant role for us but connotes computer-assisted or computer-directed proof and thus is quite distinct from *formal proof* as the topic of a special issue of the *Notices* in December 2008; see, e.g., [20].

Digital Integrity: I. For us, (g) has become ubiquitous, and we have found (h) to be particularly effective in ensuring the integrity of published mathematics. For example, we frequently check and correct identities in mathematical manuscripts by computing particular values on the LHS and RHS to high precision and comparing results—and then if necessary use software to repair defects.

As a first example, in a current study of "character sums" we wished to use the following result derived in [14]:

$$(1)\quad \sum_{m=1}^{\infty}\sum_{n=1}^{\infty}\frac{(-1)^{m+n-1}}{(2m-1)(m+n-1)^3} \stackrel{?}{=} 4\,\mathrm{Li}_4\left(\frac{1}{2}\right) - \frac{51}{2880}\pi^4 - \frac{1}{6}\pi^2\log^2(2) + \frac{1}{6}\log^4(2) + \frac{7}{2}\log(2)\zeta(3).$$

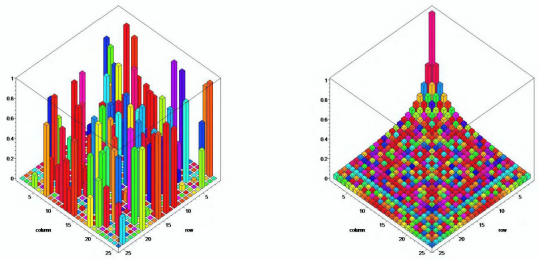
Here $\mathrm{Li}_4(1/2)$ is a polylogarithmic value. However, a subsequent computation to check results disclosed that, whereas the LHS evaluates to $-0.872929289\ldots$, the RHS evaluates to $2.509330815\ldots$. Puzzled, we computed the sum, as well as each of the terms on the RHS (sans their coefficients), to 500-digit precision, then applied the "PSLQ" algorithm, which searches for integer relations among a set of constants [16]. PSLQ quickly found the following:

$$(2)\quad \sum_{m=1}^{\infty}\sum_{n=1}^{\infty}\frac{(-1)^{m+n-1}}{(2m-1)(m+n-1)^3} = 4\,\mathrm{Li}_4\left(\frac{1}{2}\right) - \frac{151}{2880}\pi^4 - \frac{1}{6}\pi^2\log^2(2) + \frac{1}{6}\log^4(2) + \frac{7}{2}\log(2)\zeta(3).$$

In other words, in the process of transcribing (1) into the original manuscript, "151" had become "51". It is quite possible that this error would have gone undetected and uncorrected had we not been

Caption for attached graphic:

Mathematicians often work with matrices, which are arrays of numbers. When written on a page, a matrix can look like a sea of numbers, so any patterns that might occur in the numbers can be difficult to discern. More and more, mathematicians are turning to graphical representations of matrices, like the two examples here. By using color and form to indicate the values of the numbers in the matrix, these graphical representations can instantly give a sense of the patterns in the matrix. The first picture is a representation of a matrix in which the numbers exhibit a clear pattern; the second picture, by contrast, is a matrix in which the numbers are random. (Graphic by David Bailey and Jonathan Borwein. Request their permission before reproducing the graphic.)



AMS Embargoed PR

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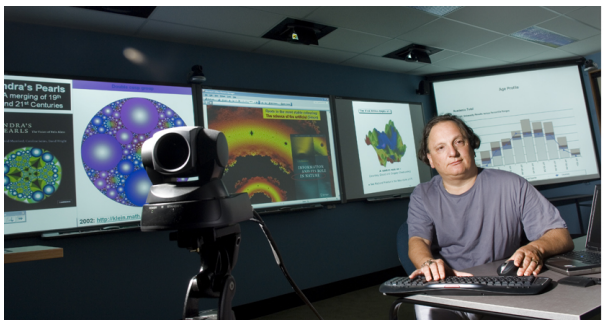
CARMA's Mandate

toc

Mathematics, as "the language of high technology" (Tom Brzustowski) which underpins all facets of modern life and current Information and Communication Technology (ICT), is ubiquitous. No other research centre exists focussing on the implications of developments in ICT, present and future, for the practice of research mathematics.

- CARMA fills this gap through exploitation and development of techniques and tools for computer-assisted discovery and disciplined data-mining including mathematical visualization.



CARMA's Access Grid Room (2008)

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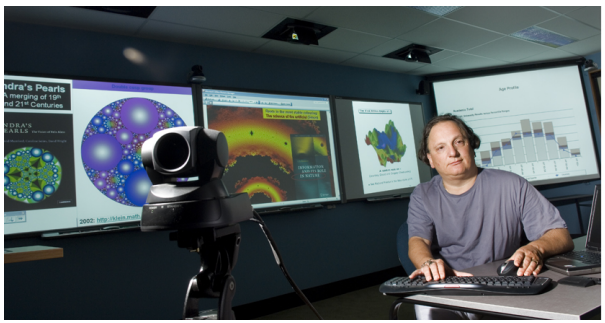

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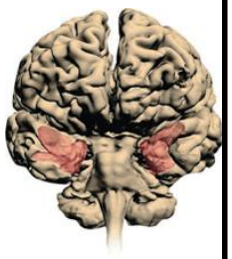

- Of mathematics underlying computer-based support systems and to undertake mathematical modelling of such activities [Also C-OPT (RIP), NUOR & partners]
- To promote and advise on use of appropriate tools (hardware, software, databases, learning object repositories, mathematical knowledge management, collaborative technology) in academia, education and industry [Global Success, locally less so]
- To make University of Newcastle a world-leading institution for Computer Assisted Research Mathematics and its Applications[1]

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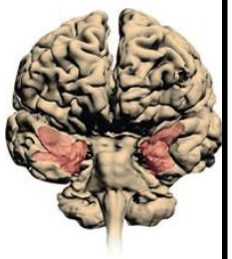

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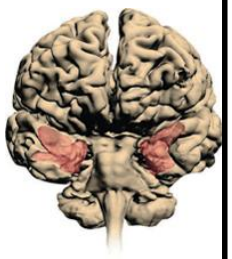

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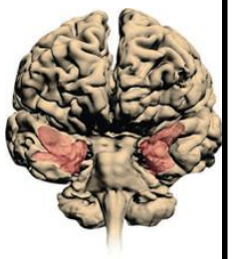

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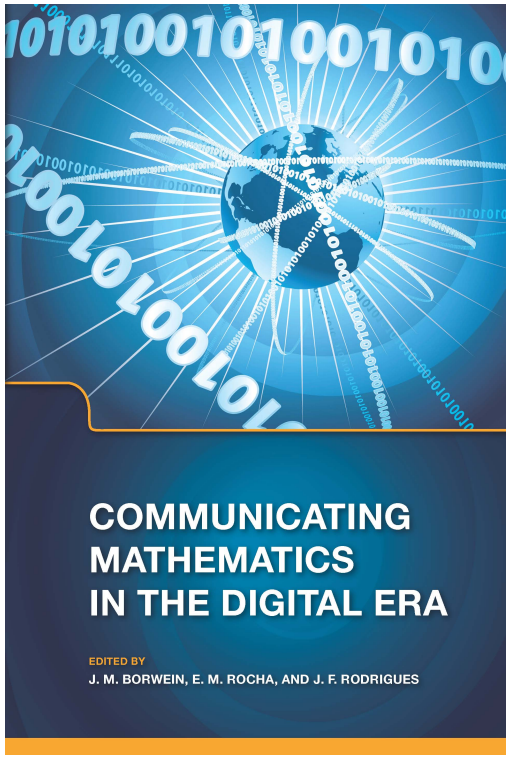
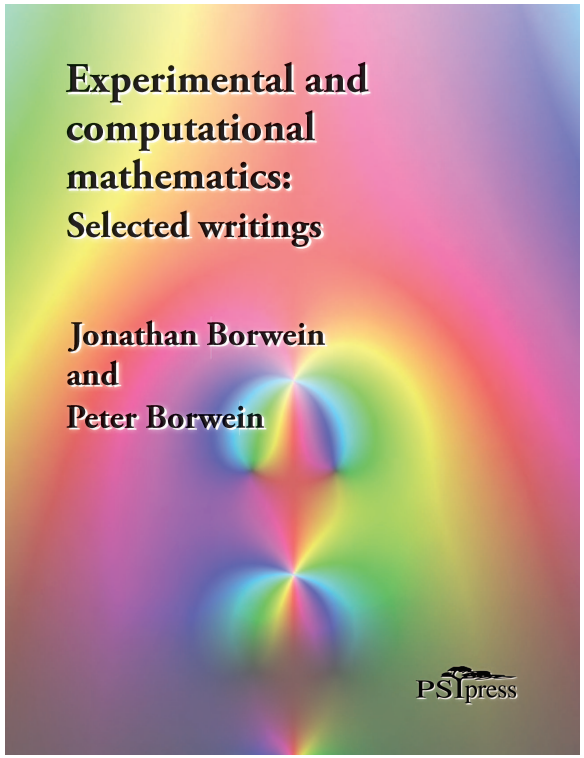
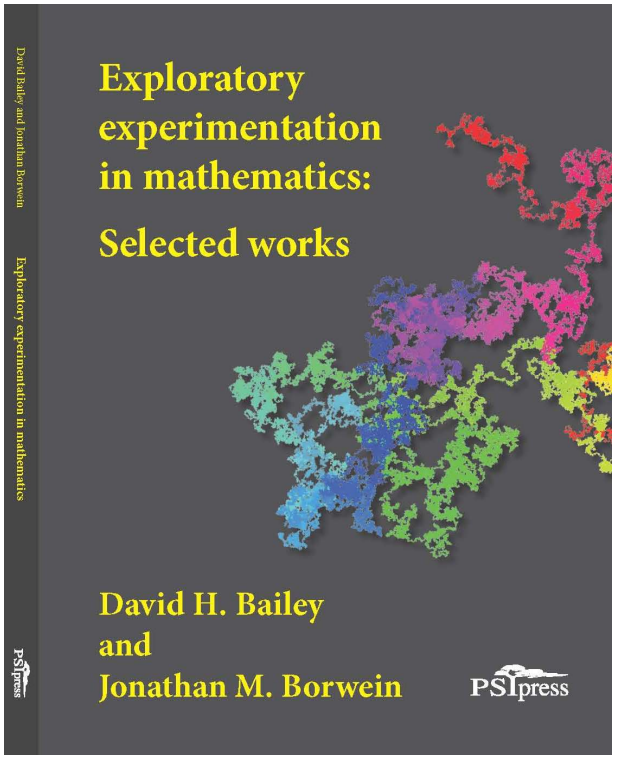
Communication and Computation: are entangled







Communicating Mathematics (2008, 2010, 2012)

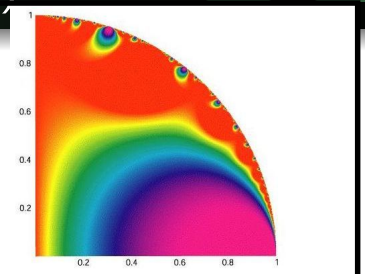
- 2012 *Science Communication* paper on AG seminars at `http://www.carma.newcastle.edu.au/jon/c2c11.pdf`

CARMA

II. CARMA's Deep History (Daniel Lord Smail)

A co-evolution of symbolic/numeric (hybrid) computation, experimental maths, collaborative technology and **HPC**.

Experimentally-found modular fractal took 3 hrs to print



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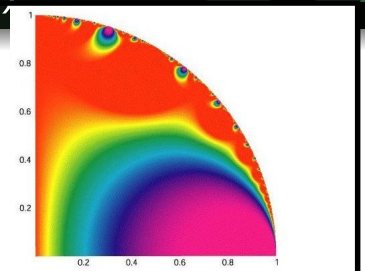

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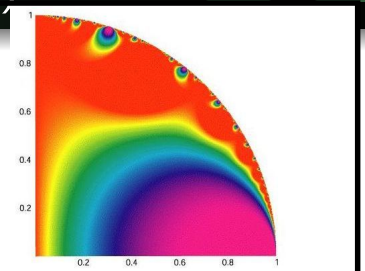

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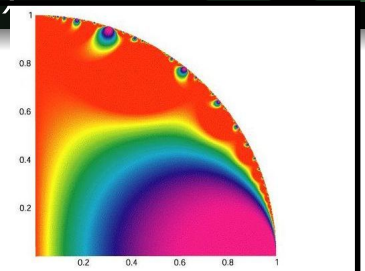

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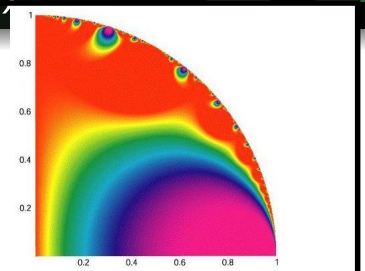

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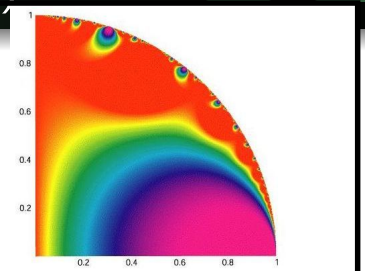

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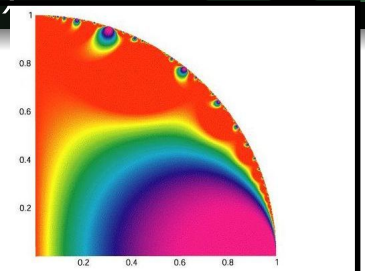

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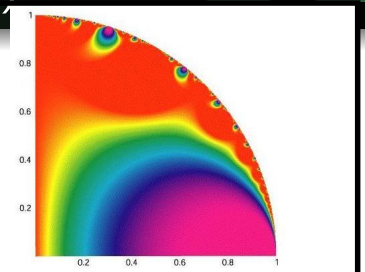

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CARMA's Structure and Membership

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Currently **36** Members, 8 Associates, 7 Student Members:

- Steering Committee (George Willis Deputy Director)
- External Advisory Committee (IBM (GAJ chair), Melb, LBL)
- Scientific, Administrative and AGR Officers
- Members and Students from Newcastle and Associate Members from Everywhere:

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Frequent visitors: both student and faculty, short and long-term

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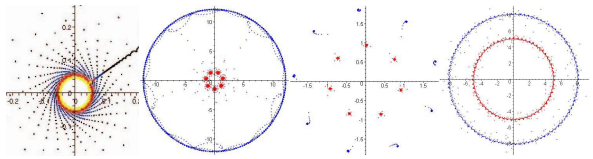

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  - Trans Pacific Workshop: with UBC-O and SFU (monthly-ish)
  - Short Lecture Series (2-5 lectures)

    2010 Rockafellar *Risk* and Diestel *Haar measure*
    2011 Cominetti *Scheduling* and Zhu on *Finance*
    2012 Lasserre *Moment problems*, **2013** Ioffe *Nonlinear analysis*
  - 2013 Honours courses(360hr) Seminars(150hr) Outreach(30hr)

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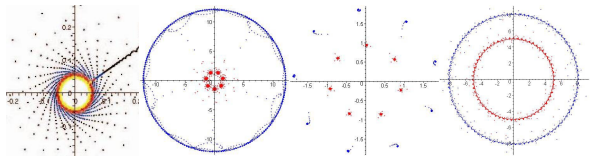

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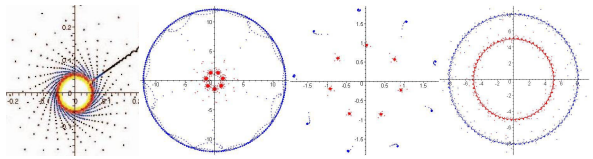

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- **International Workshops and Conferences**: including
  - IP Down Under for INFORS 2011 (July 2011)
  - van der Poorten memorial meeting (March 2012), EViMS (Nov) and ICERM (Dec)
  - ANZIAM 13 (Feb 3-7), SPOM (Feb 9-12) & MPE13 (July)
  - **2013–14** Six more Workshops (1 at ICERM) and Student Conf. All have some external funding.
    - **Sept 13**. Hickson (Infectious Diseases)
    - **Oct 13**. Coons (Number Theory Down Under)
    - **Feb 14**. Meylan (Waves)
    - **June 14**. Elder (Geometric and Asymptotic Group Theory)
    - **July 14**. Borwein (Experimental maths at ICERM)
    - **July 14**. Tam (Annual national student conference)
  - Many sessions coorganized at ANZIAM and AustMS annual meetings

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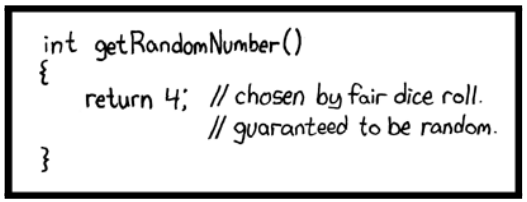

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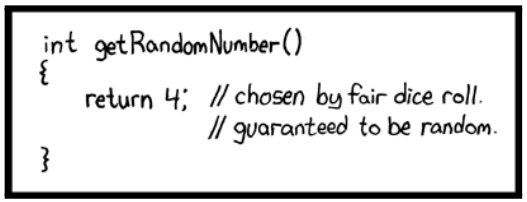

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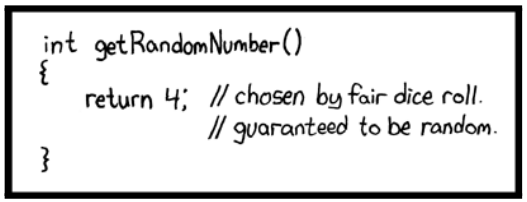

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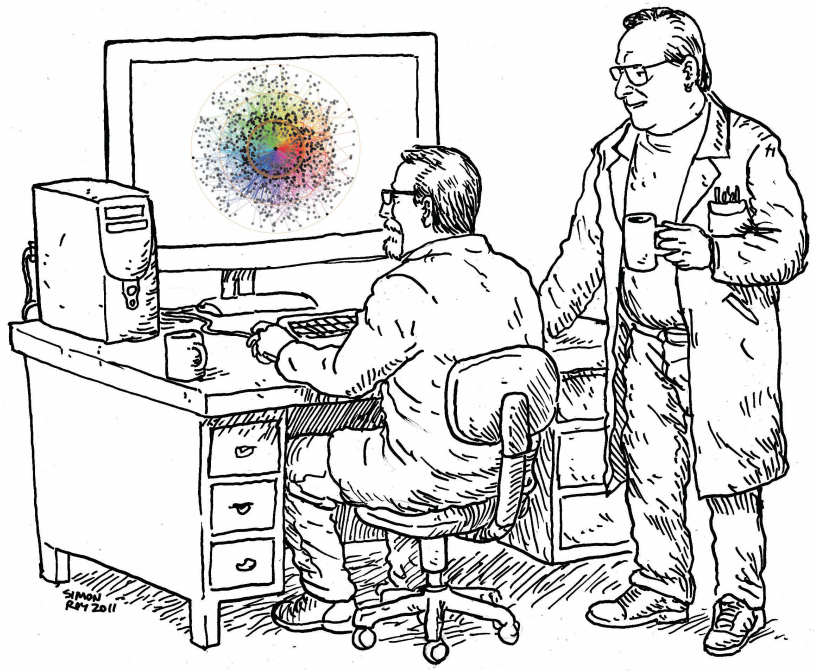
III. Presentations on Current Research by Steering Committee

1. **Pure** (George Willis and Murray Elder)
2. **Applied** (Mike Meylan and Roslyn Hickson)
3. **Education** (Judy-anne Osborn)



"Sometimes it is easier to see than to say."

- See also `http://carma.newcastle.edu.au/pdf/retreat2013programme.pdf` and its links

Purer Research . . . some recent achievements

1. **2011** Future Fellow (Murray Elder)
2. Zudilin promoted July **2013**: One L/Prof, Two Profs, One A/Prof
3. Six current ARC Discovery Grants
4. **2011** Founding CARMA Optimization RA Miroslav Bacak moves to Max Planck Leipzig as biomathematics researcher
5. **2011** Mirka Miller wins VC's award for supervision including 4 of top 10 Indonesian mathematicians **2013**
6. **2011-13** Three books coauthored by RHD students James Wan Lattice Sums (CUP) and Matt Skerritt Modern Mathematical Computation with Maple and with Mathematica (Springer)
7. **2011** Outstanding Academic Title of *Choice*, the American Library Association, for Convex Functions (CUP) by JMB & Jon Vanderwerff
8. Two first rate PhDs in Number Theory (Wan **2013** & Straub **2012**). Wan won **2011** AustMS Neumann prize(2nd for UofN. Tam **2013** hon. mention (5/76).) Straub won **2011** ACM-ISSAC best student paper.
9. RHD student Michael Rose appears frequently on ABC-Newcastle radio. His *Explainer* on Chaos is in The Explainer: From Déjà Vu to Why the Sky Is Blue, and Other Conundrums (CSIRO, Sept **2013**).
10. **2013** Miller starts the Electronic Journal of Graph Theory and Applications
11. **2013** Coons releases The Kurt Mahler Archives in honour of van der Poorten: Neverending Fractions (JMB, **vdP**, Shallit, Zudilin) finished.
12. Matt Tam awarded **2013** Vice-Chancellor's Award for Outstanding Research Candidates

CARMA

Purer Research . . . recent and upcoming achievements

1. **2011-13** participated in five (unsuccessful) CRC bids
2. Sept **2013** Aragon starts 5 year EU/NIH RA in Luxembourg. Was **2012** poster finalist in the NSF Visualization Challenge
3. Oct **2013** two issues of flagship journal Mathematical Programming and Computational and Analytic Mathematics published by Springer in honour of JMB's 60th birthday
4. Jan **2014** Lamichhane gives course at AMSI summer school. (Lectures for third year in a row.)
5. Jan-June **2014** Willis co-organizes Thematic semester on Harmonic Analysis at Fields Institute Toronto. (His ground breaking research over past two decades is increasingly being recognized.)
6. March **2014** Osborn to lecture as one of the AAS Science Stars of Tomorrow

CARMA

Purer Research . . .

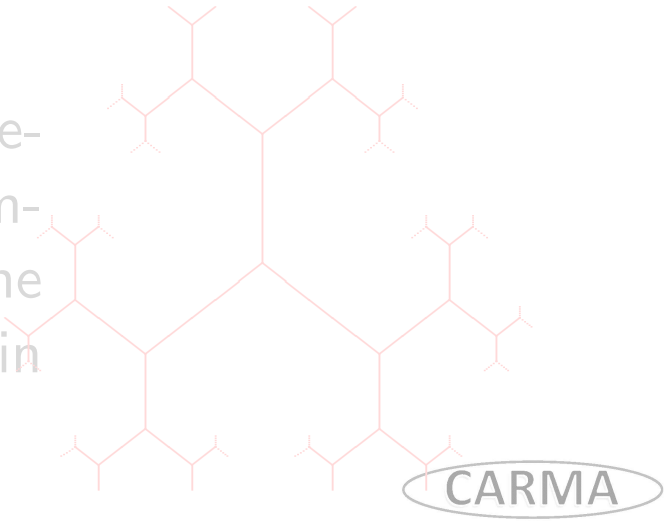
1. Number Theory Best results on irrationality of ζ-values. Analysis and visualisation of computational complexity. Foremost group nationally with an outstanding international profile in number theory.

Borwein, Brent, Coons, Mumtaz (RA), Zudilin

$$\zeta(s) = \sum_{n=1}^{\infty} \frac{1}{n^s} = \prod_{p \text{ prime}} \frac{1}{1-p^{-s}}$$

2. Algebra and Symmetry Break-though theoretical and computational tools. Types of symmetry of discrete structures being charted. The group leads an international research program in the field.

Elder, Reid (RA), Willis



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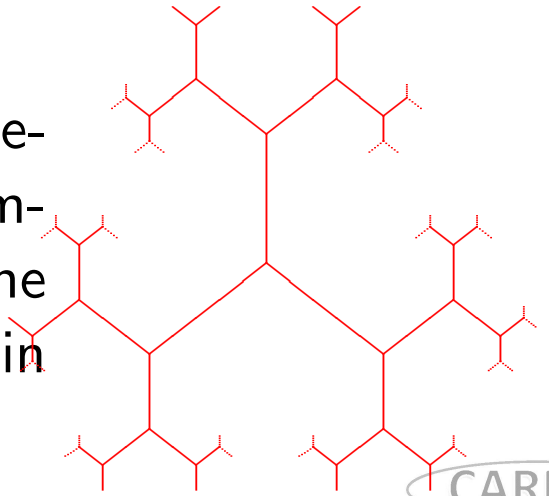

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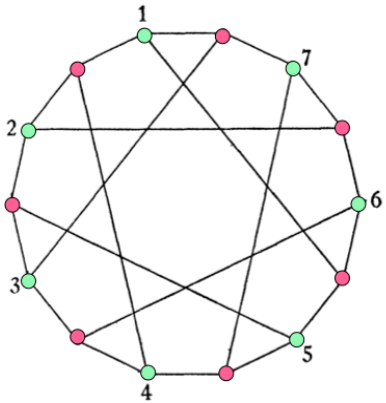
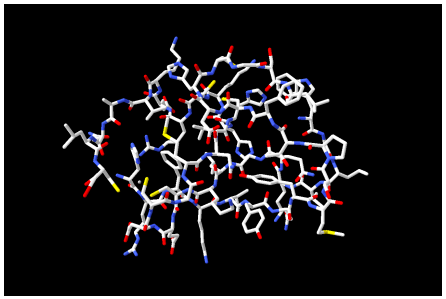


3. Combinatorics and Discrete Maths Finite patterns with high levels of structure, and their links with algebra, geometry and computing. A group of researchers having international reputations for excellence. Many applications to encryption, privacy, security, ...

Alspach, Brankovic, Brent, Miller, Osborn



Matt Tam's movie:

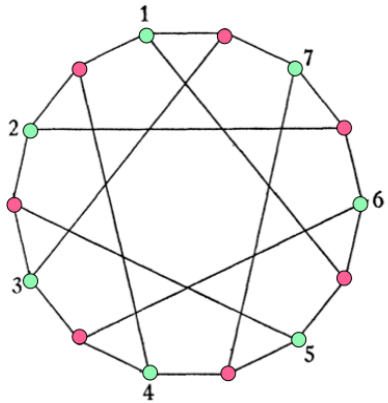
http://carma.newcastle.edu.au/DRmethods/1PTQ.html

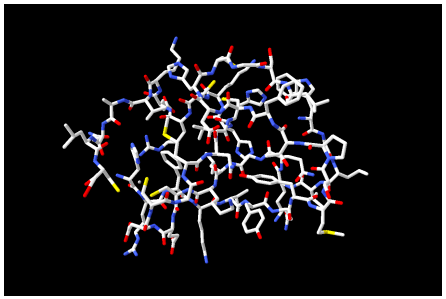
4. Analysis and Optimisation Geometric and infinite-dimensional techniques underpinning optimisation, modelling of continuous structures and signal processing. Researchers having at least international reputations for innovative techniques. Applications are endless.

Aragon(RA), Borwein, Hogan, Sims, Willis, Yao(RA)

CARMA

Purer Research within CARMA





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3. Combinatorics and Discrete Maths Finite patterns with high levels of structure, and their links with algebra, geometry and computing. A group of researchers having international reputations for excellence. Many applications to encryption, privacy, security, ...

Alspach, Brankovic, Brent, Miller, Osborn

4. Analysis and Optimisation Geometric and infinite-dimensional techniques underpinning optimisation, modelling of continuous structures and signal processing. Researchers having at least international reputations for innovative techniques. Applications are endless.

Aragon(RA), Borwein, Hogan, Sims, Willis, Yao(RA)

Applied Research . . .

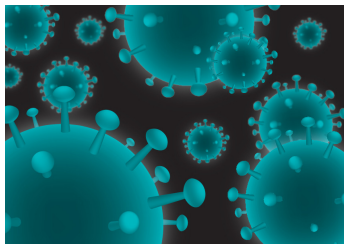
"It says it's sick of doing things like inventories and payrolls, and it wants to make some breakthroughs in astrophysics."

1. Hickson
2. Meylan
3. Lamichhane
4. Other

CARMA

Infectious Disease Modelling (Roslyn Hickson's current projects)

1. Incorporating population heterogeneity in susceptibility and infectivity in an SIR model
   - Case study on influenza
2. Understanding a co-epidemic of TB and adult diabetes
   - A case study in Kiribati, Pacific Islands
3. Modelling of dengue fever control by introducing Wolbachia into *Aedes aegypti*
   - Predicting the effect of trials in Far North QLD



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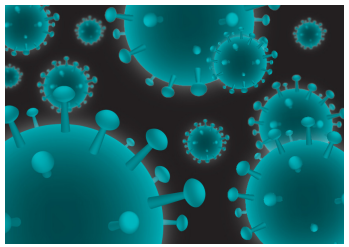

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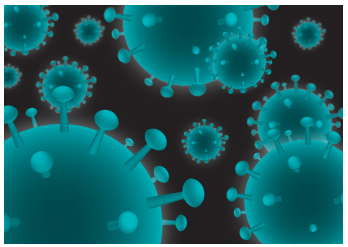

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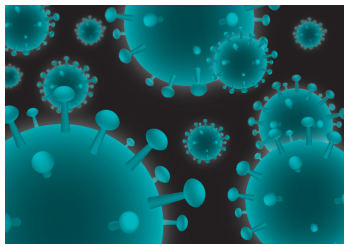

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Differential Equations at CARMA (Meylan & Lamichhane)

$$\frac{\partial^2 u}{\partial t^2} = c^2 \nabla^2 u \quad \text{(Wave Equation)}$$

- Partial differential equations are used in a huge range of mathematical models
  - numerically and qualititively
- Mathematics group is building applied strength in this area. We are seeking to connect and build on the strong research in the engineering school
  - CDSC interaction is already strong (e.g., AMZIAM-AMSI lecturer, Steve Boyd, visit in Sept is cosponsored)]

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1. Waves theory finds application in diverse areas ranging from coastal erosion to telecommunication, from medical imaging to quantum physics
2. Feb 2014. CARMA will host an International AMSI-CARMA conference on Wave Science organised by Michael Meylan
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Wave-induced break up of Antarctic sea ice (Meylan)

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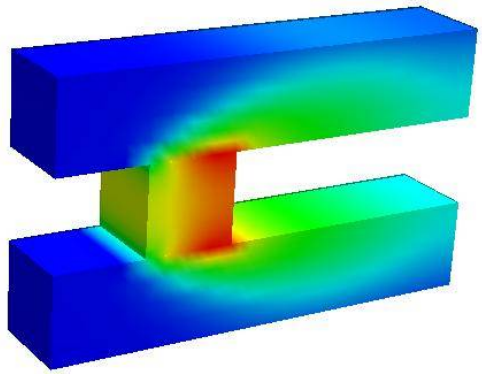

Heat generated by friction simulated by FEM (Bishnu)

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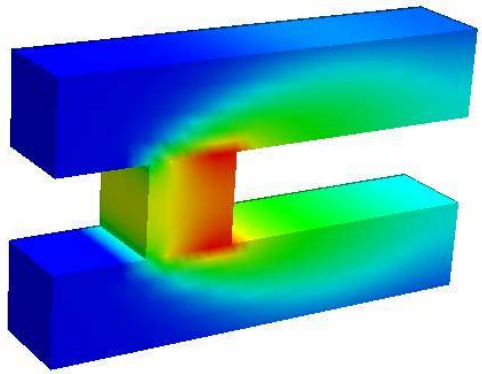

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Other 'applied' Collaborations within UofN (JMB)

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2. Chemistry (Borwein-Sims-Tam) Structure of ionic liquids
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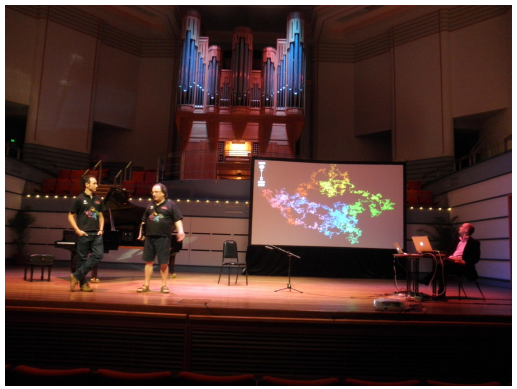

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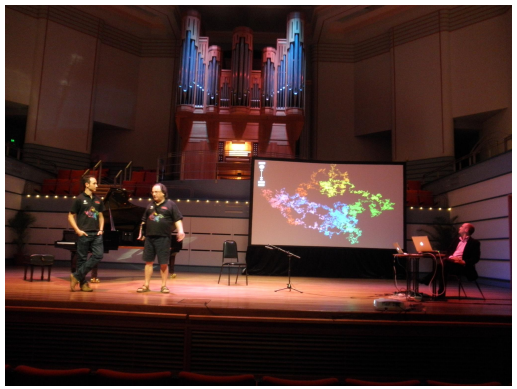

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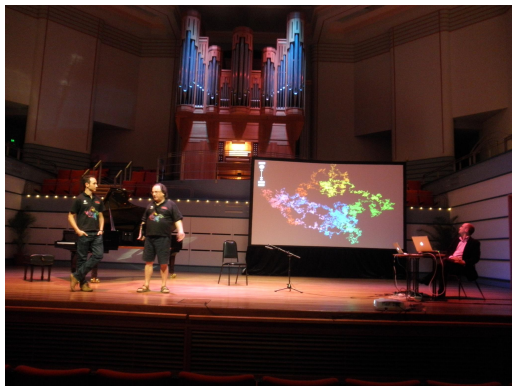

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NUMERIC . . .

Our newest formal research group:

`http://numeric.carma.newcastle.edu.au/`

CARMA

Grant success by NUMERIC members includes:

"Inspiring Mathematics and Science in Teacher Education"

- a project in partnership with: *the Universities of Queensland, Sydney, Tasmania, Wollongong, and James Cook University.*
- Funding: $2.2million over 3 years from OLT starting Jan 2014
- Aims:
  - genuine collaboration of mathematical and education scholars
  - institutionalise new ways of integrating science and pedagogy
- Focuses:
  - Recruitment of more science and maths students into teaching
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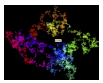
CARMA advancing the next generation through:

- *Inspiring Mathematical Science through the Media* - *art, radio interviews, public talks, blogs, reviews, books, book chapters*


Fran Aragon


Jon Borwein

WIRED SCIENCE BLOGS / SOCIAL DIMENSION
Jon Borwein

THE CONVERSATION
Expert news and views

Book Chapter on Mathematics of Zombies - release 2014
Judy-anne Osborn

ScienceNews
MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC

Film review:

- *Maths and Engineering Competitions and Challenges*

APSMO
Australasian Problem Solving Mathematical Olympiads
Brailey Sims, Matt Tam

science and engineering challenge
Roslyn Hickson

Australian Mathematics Trust
Enriching Mathematics Learning
Andrew Kepert

- *Education research, shared RHD students, education competitions and prizes*

Educational research by NUMERIC members;
Joint RHD students with Education, one soon to finish, another starting in 2014.
Jon Borwein, Kathryn Holmes, Judy-anne Osborn, Elena Prieto, Brailey Sims

UoN Teaching Awards
Mike Meylan, Mal Roberts

informs Case and Teaching Materials Competition
2014 finalist: Masoud Talebian

- *Show and Tells - we visit schools and vice versa*

Mathematicians in Schools
David Allingham Ian Benn Murray Elder Jeff Hogan

AIM High Year 6 Discover Uni Day
Judy-anne Osborn, Brailey Sims, Matt Skerritt, Matt Tam, Michael Rose

SCHOOLS VISIT DAY
NEWCASTLE - WEDNESDAY 17 JULY 2013
JOIN US AT UON FUTURE STUDENTS:

David Allingham, Jon Borwein, Roslyn Hickson, Kathryn Holmes, Andrew Kepert, Judy-anne Osborn, Malcolm Roberts, Brailey Sims

NORTHERN TERRITORY SENIOR SCHOOL ENRICHMENT SEMINARS
Thomas Kalinowski

Maths Enrichment for Yr 9-10 students/CARMA Young Mathematicians Program
Jeff Hogan, Malcolm Roberts, Judy-anne Osborn, Michael Rose

- *Relationships and community-building*

aamt
THE AUSTRALIAN ASSOCIATION OF MATHEMATICS TEACHERS INC.
supporting and promoting mathematics education
Malcolm Roberts

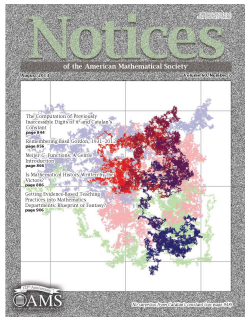
Newcastle University Maths Society
Mathematical Film Nights
CARMA
Jon Borwein, Judy-anne Osborn, Brailey Sims, George Willis

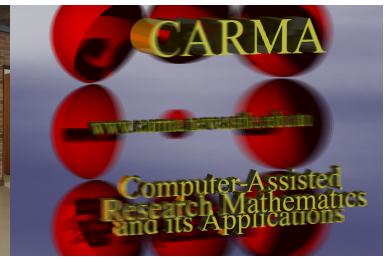
IV. Animation, Simulation and Stereo ...

See `http://vis.carma.newcastle.edu.au/`: Stoneham movie

> *The latest developments in computer and video technology have provided a multiplicity of computational and symbolic tools that have rejuvenated mathematics and mathematics education. Two important examples of this revitalization are experimental mathematics and visual theorems* — *ICMI Study* **19** (2012)







Cinderella, 3.14 min of Pi, Catalan's constant and Passive 3D

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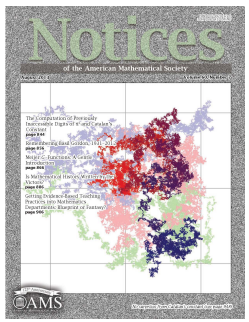

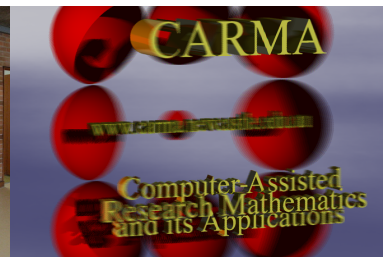

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Visualisation at CARMA ... often seeing is discovering

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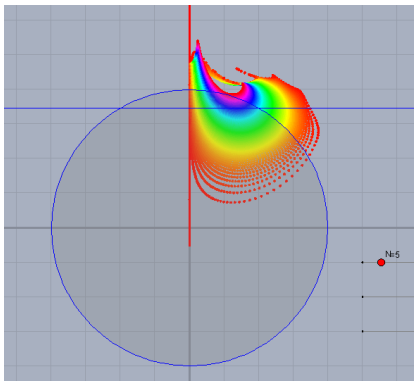
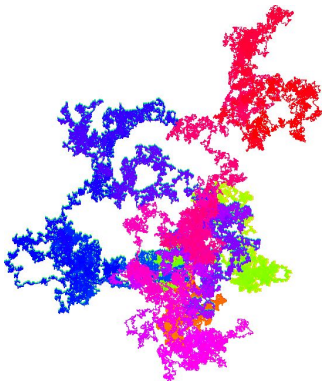
  - using dynamic geometry software, animations, computer algebra, etc.





Left: 20 thousand iterations viewed simultaneously. Right: a base-4 number as a walk

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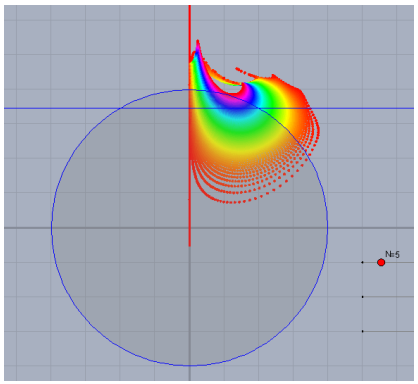

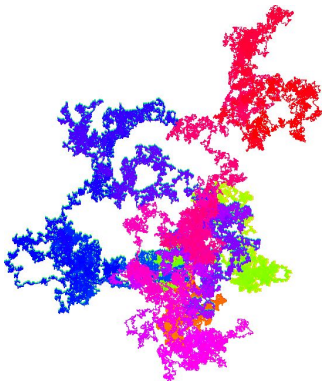

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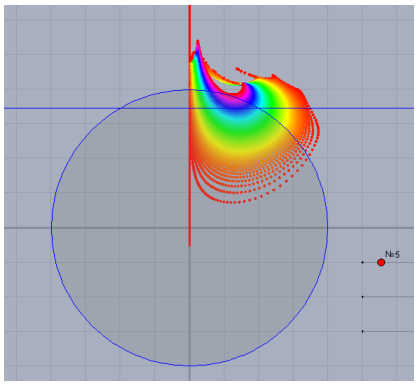

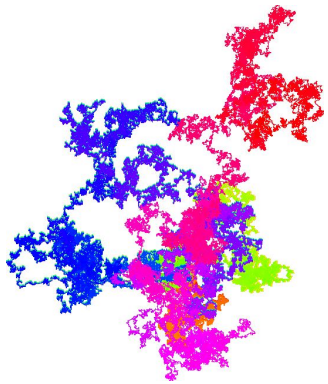

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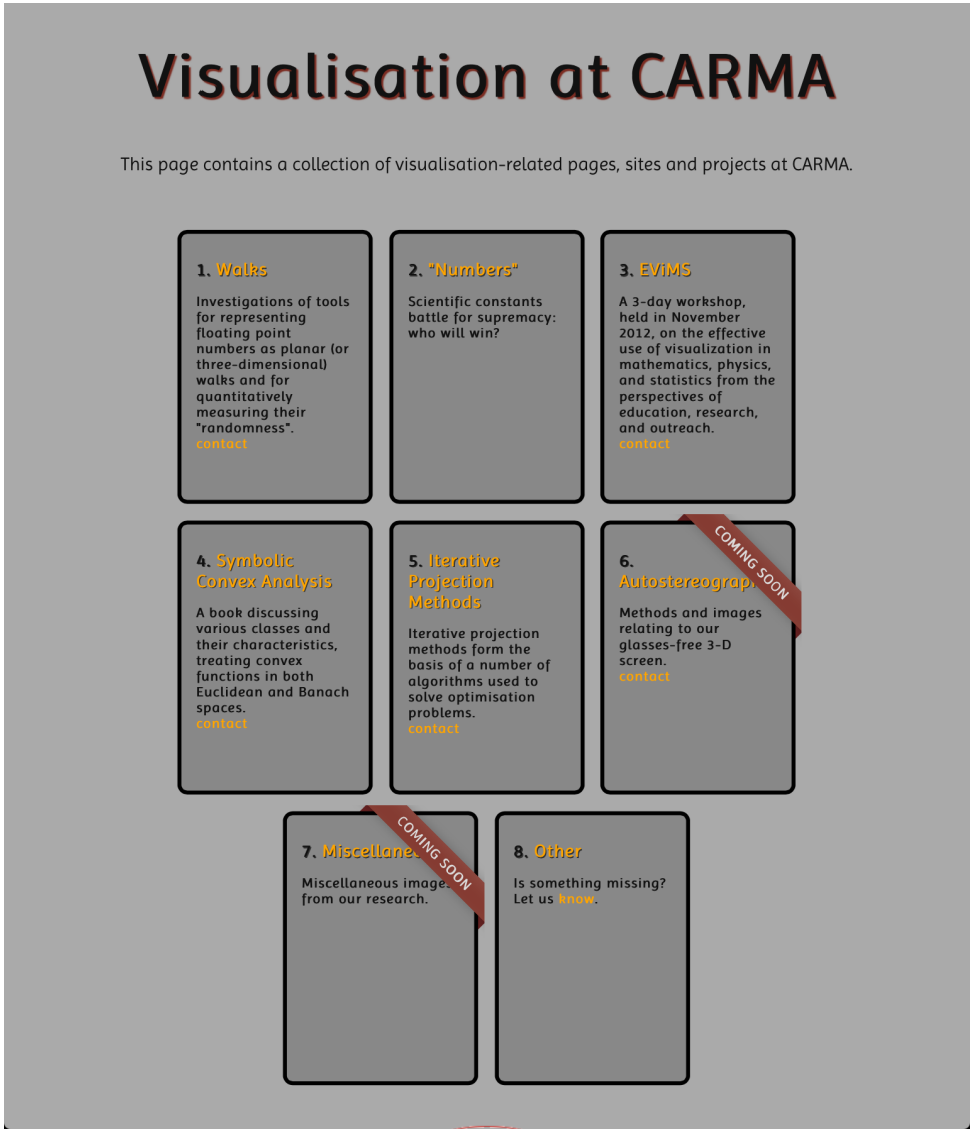

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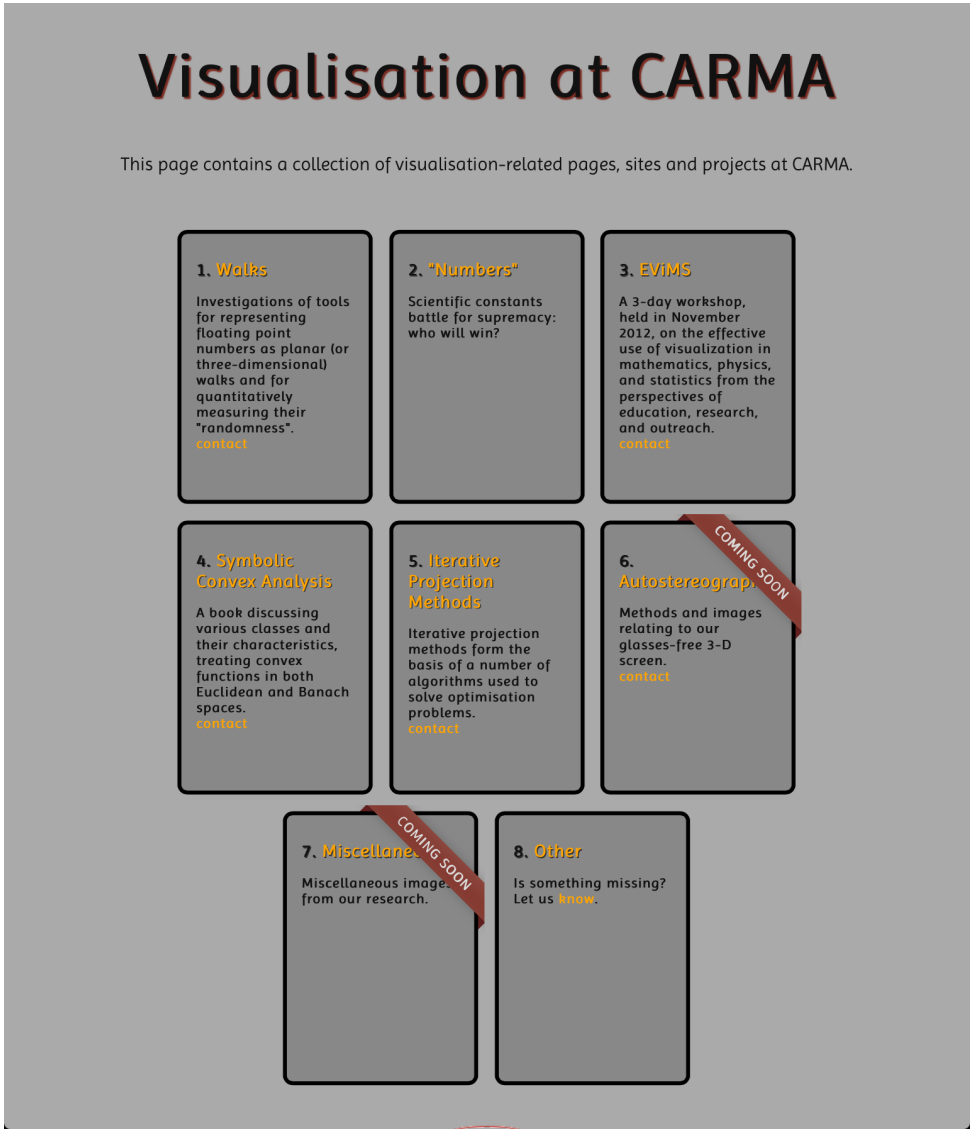

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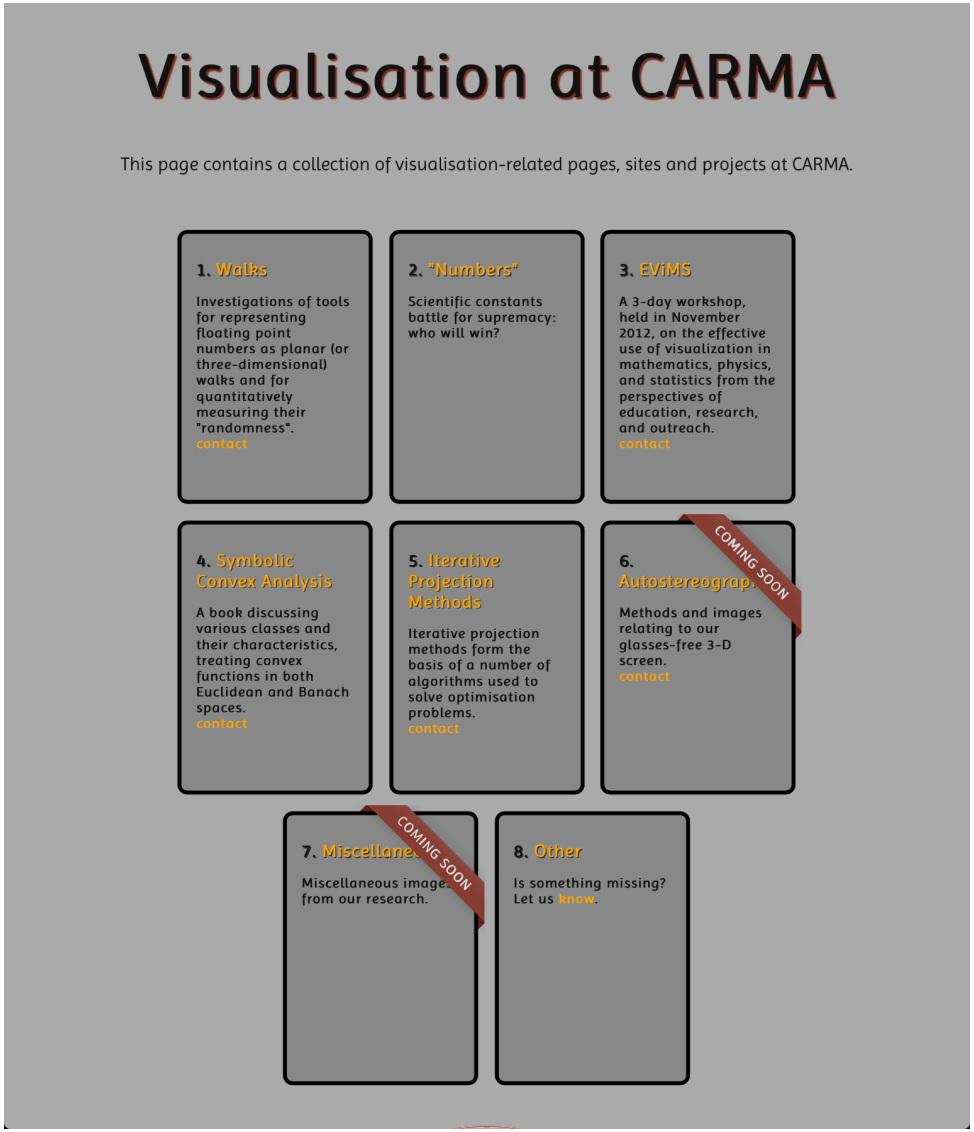

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Allingham, Danson, & Turner

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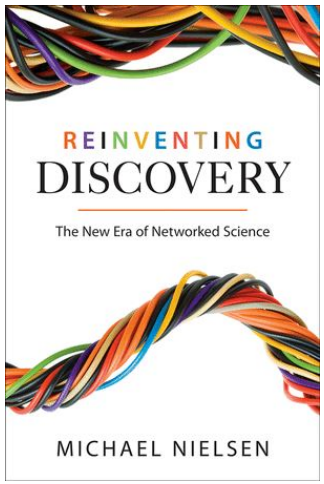
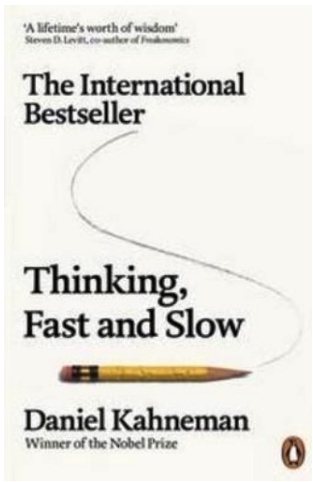
  - Relying on significant subsidy from the director's other funds





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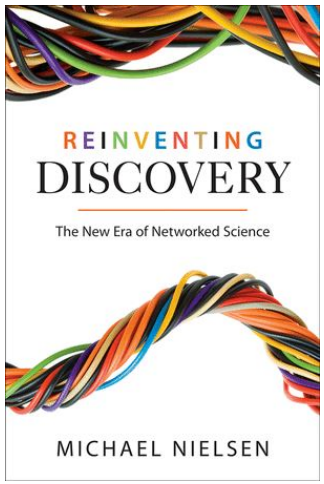

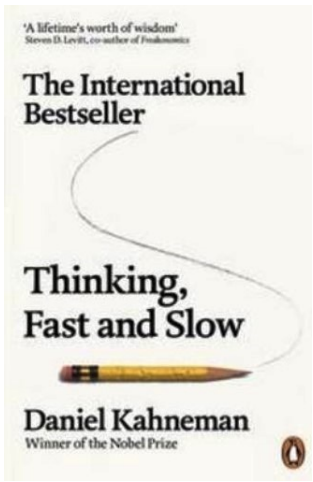

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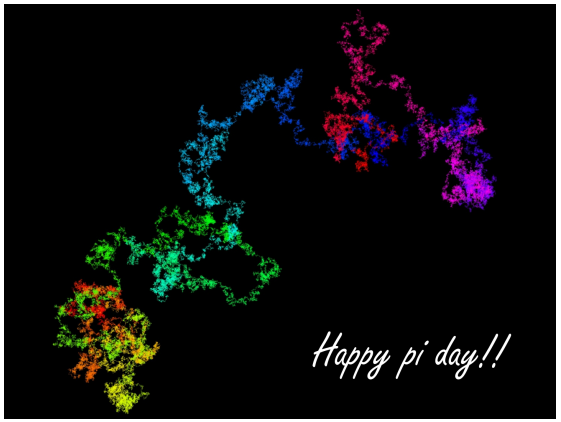
Conclusions

We are having fun

- We are Pragmatic Dreamers
  - always aiming slightly too high
- The members' enthusiasm and work ethos is superb. We all *own* CARMA
- We cover all bases - research, applications, outreach and education
  - We can not fund education. I am, however, strongly in favour of early introduction to research.

    (Eliot Phillipson, former CFI and CIHR President)
  - an AMSI 'maths hot spot' (one of two). Very strong participation at AustMS, ANZIAM and AMSI conferences

2012 CARMA shirts (Ballarat AMS)



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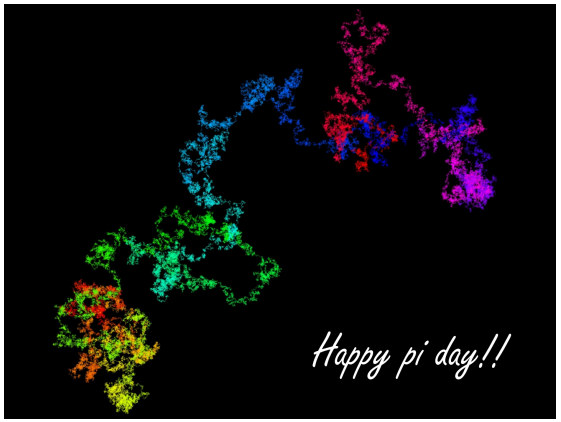

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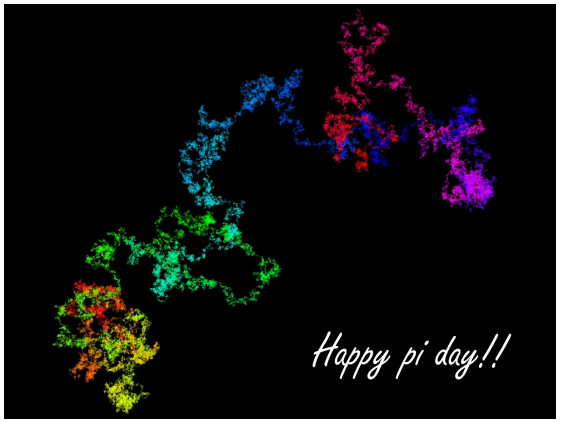

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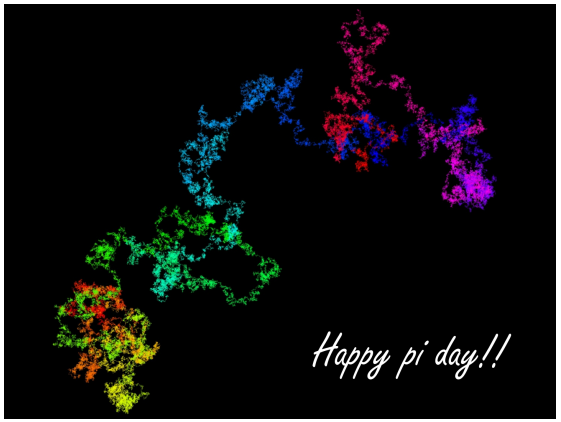


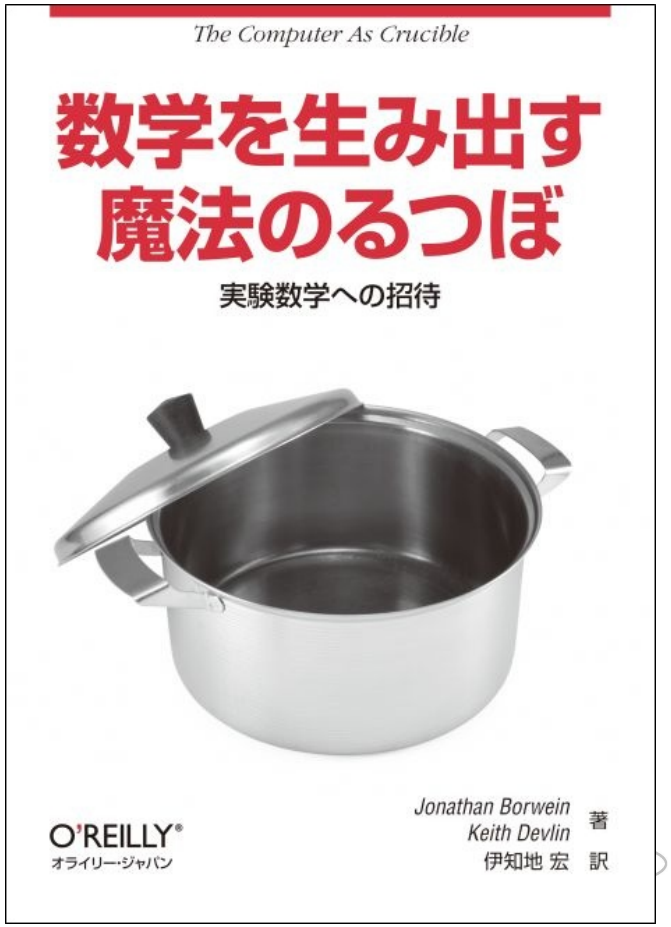
CARMA

Not bad for the first five years ... and we have big plans

Given *real* support from P/VC for:

- hiring next CARMA Director/HoS;
- to make Pure Maths an ERA '5'; Maths a top 100 department.

2010: Communication is not yet always perfect



Related Material

1. Feasibility Methods: Divide and Concur
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2. Experimental Mathematics: for Everything
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3. Pi Day:
   http://carma.newcastle.edu.au/jon/piday.pdf
4. Walking on Numbers: a Viral Success
   http://walks.carma.newcastle.edu.au/
5. Lattice Sums: Then and Now
   http://www.carma.newcastle.edu.au/jon/LatticeSums/index.html
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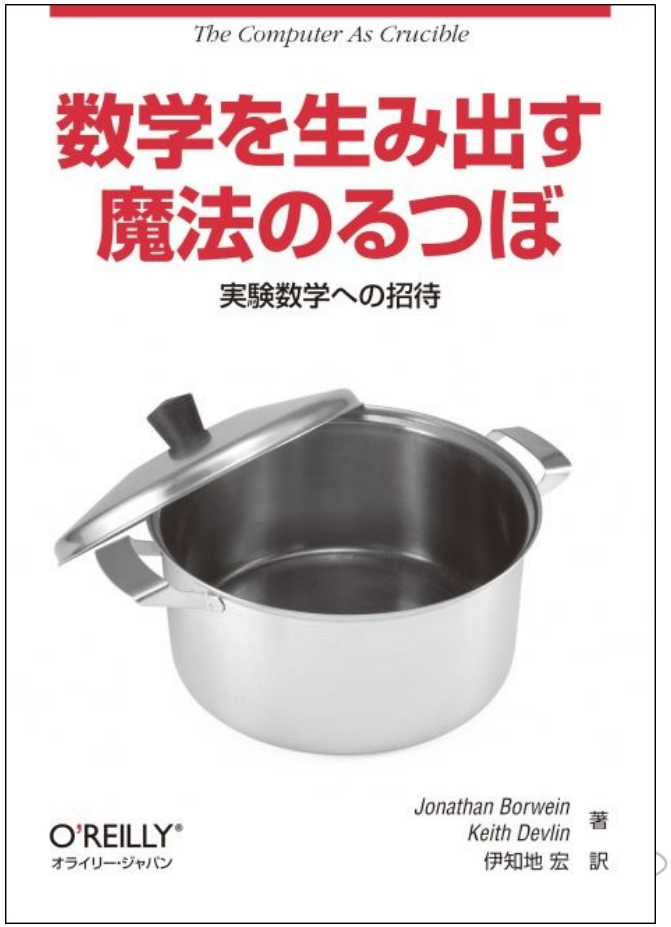

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