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


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

5. CARMA’s Remit
13. About CARMA
18. Research within CARMA
32. Visualization and Data Mining at CARMA
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
Contents

1. 5. CARMA’s Remit
   5. Experimental Mathematics
   10. CARMA’s Mandate
   11. CARMA’s 2008 objectives
   12. Communication, Computation and Collaboration

2. 13. About CARMA
   13. CARMA’s Background
   14. CARMA Structure
   15. CARMA Activities
   17. CARMA Services and Resources

3. 18. Research within CARMA
   19. Some Recent Successes
   21. Purer Research within CARMA
   23. More Applied Research within CARMA
   29. Maths Education Research within CARMA

4. 32. Visualization and Data Mining at CARMA
   32. Animation, Simulation, 3D
   33. Visualisation at CARMA
   35. Member Services
   36. Conclusions
CARMA’s Leadership

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)

- Government, Industry and Academia: Australia and Overseas
- All have close connections with Newcastle
- Apologies: Joseph, Miller, Sims, Turner, Zudilin, ...
CARMA’s Leadership

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)

- Government, Industry and Academia: Australia and Overseas
- All have close connections with Newcastle
- Apologies: Joseph, Miller, Sims, Turner, Zudilin, ...
CARMA’s Support Staff

They make our activities possible
- with unfailing good grace, imagination and energy
- AGR is a misnomer: it is really an ACE

Mrs Juliane Turner (EA)  Dr David Allingham (Scientific officer)  Andrew Danson (‘AGR’)
CARMA’s Support Staff

They make our activities possible

- with unfailing good grace, imagination and energy
- AGR is a misonmer: it is really an ACE
CARMA’s Support Staff

They make our activities possible
  – with unfailing good grace, imagination and energy
  – AGR is a misnomer: it is really an ACE
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)

• Quoted in International Council on Mathematical Instruction Study 19: On Proof and Proving, 2012
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)

- Quoted in International Council on Mathematical Instruction
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

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

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

- If $a_0 \neq 0$ then (1) assures $\beta$ is in rational vector space generated by $\{\alpha_1, \alpha_2, \ldots, \alpha_n\}$.
- $\beta = 1, \alpha_i = \alpha^i$ means $\alpha$ 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))

Madelung constant (2013 book)
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

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

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

- If $a_0 \neq 0$ then (1) assures $\beta$ is in rational vector space generated by $\{\alpha_1, \alpha_2, \ldots, \alpha_n\}$.
- $\beta = 1, \alpha_i = \alpha^i$ means $\alpha$ 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))

Madelung constant (**2013** book)
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

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

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

- If $a_0 \neq 0$ then (1) assures $\beta$ is in rational vector space generated by $\{\alpha_1, \alpha_2, \ldots, \alpha_n\}$.
- $\beta = 1, \alpha_i = \alpha^i$ means $\alpha$ 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))

CMS D. Borwein Prize

Madelung constant (2013 book)
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

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

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

- If $a_0 \neq 0$ then (1) assures $\beta$ is in rational vector space generated by $\{\alpha_1, \alpha_2, \ldots, \alpha_n\}$.
- $\beta = 1, \alpha_i = \alpha^i$ means $\alpha$ 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))
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.
5. 1957: The Fortran Optimizing Compiler. Turns high-level code into efficient computer-readable code.
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.

Experimental Mathematics: PSLQ is core to CARMA

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

—Jeff Shallit

Exploratory Experimentation and Computation

David H. Bailey and Jonathan M. Borwein

The computer as crucible [13] writes. A bit less informally, by experimental mathematics we intend [10]:

(a) gaining insight and intuition;
(b) visualizing new relationships;
(c) discovering new relationships;
(d) testing and verifying conjectures;
(e) finding a possible result to see if it meets 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 it requires computer-assisted or computer-directed proof and thus is quite distant from formal proof as the topic of a special issue of the Notices in December 2008; see, e.g., [20].

Digital Integrity. For us, q4 becomes ubiquitous, and we have found (b) to be particularly effective in ensuring the integrity of published mathematics. For example, we frequently check and correct identities in mathematical manuscripts by comparing particular values on the LHS and RHS to 50,000 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)

\[
\sum_{n=1}^{m} \frac{(-1)^{n}}{(2m - 1)(m + 1)} = \frac{1}{4} \sum_{j=1}^{m} \left[ \frac{1}{j} \frac{m}{2} \right] - \frac{1}{4} \sum_{j=1}^{m} \frac{1}{j} \frac{m}{2} \log(2) + \frac{1}{4} \sum_{j=1}^{m} \frac{1}{j} \frac{m}{2} \log(2) + \frac{1}{4} \sum_{j=1}^{m} \frac{1}{j} \frac{m}{2} \log(2)
\]

Here \(L_{i}(1/2)\) is a polylogarithmic value. However, a subsequent comparison to check results failed, whereas the LHS evaluates to 0.867202289... and the RHS evaluates to 2.565383415... 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 full BSAL algorithm, which searches for integer relations among a set of constants [10]. PSLQ quickly found the following:

(2)

\[
\sum_{n=1}^{m} \frac{(-1)^{n}}{(2m - 1)(m + 1)} = \frac{1}{4} \sum_{j=1}^{m} \left[ \frac{1}{j} \frac{m}{2} \right] - \frac{1}{4} \sum_{j=1}^{m} \frac{1}{j} \frac{m}{2} \log(2) + \frac{1}{4} \sum_{j=1}^{m} \frac{1}{j} \frac{m}{2} \log(2) + \frac{1}{4} \sum_{j=1}^{m} \frac{1}{j} \frac{m}{2} \log(2)
\]

In other words, the process of truncating (1) into the original manuscript, "151" had become "2132", it is quite possible that this error would have gone undetected and uncorrected had we not been
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 Mandate

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)
CARMA’s 2008 Objectives:

To perform R&D relating to the informed use of computers as an adjunct to mathematical discovery (including current advances in cognitive science, in information technology, operations research and theoretical computer science)

- 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

\(^1\)ERA: UofN only 2010 ‘5’ in Appl. Maths & only real 2012 ‘5’ (else) 2013 Top 200 Maths Department (Shanghai)
CARMA’s 2008 Objectives:

To perform R&D relating to the informed use of computers as an adjunct to mathematical discovery (including current advances in cognitive science, in information technology, operations research and theoretical computer science)

- 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

1ERA: UofN only 2010 ‘5’ in Appl. Maths & only real 2012 ‘5’ (of 2) 2013 Top 200 Maths Department (Shanghai)
CARMA’s 2008 Objectives:

To perform R&D relating to the informed use of computers as an adjunct to mathematical discovery (including current advances in cognitive science, in information technology, operations research and theoretical computer science)

- 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

\(^1\)ERA: UofN only 2010 ‘5’ in Appl. Maths & only real 2012 ‘5’ (\(\geq\)10), 2013 Top 200 Maths Department (Shanghai)
CARMA’s 2008 Objectives:

To perform R&D relating to the informed use of computers as an adjunct to mathematical discovery (including current advances in cognitive science, in information technology, operations research and theoretical computer science)

- 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

---

1ERA: UofN only 2010 ‘5’ in Appl. Maths & only real 2012 ‘5’ (of 2)
2013 Top 200 Maths Department (Shanghai)
CARMA’s 2008 Objectives:

To perform R&D relating to the informed use of computers as an adjunct to mathematical discovery (including current advances in cognitive science, in information technology, operations research and theoretical computer science)

- 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

\[1 \text{ERA: UofN only 2010 ‘5’ in Appl. Maths & only real 2012 ‘5’ (of 2) 2013 Top 200 Maths Department (Shanghai)} \]
Communication and Computation: are entangled


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

1982 PBB & JMB ‘minor’ work on fast computation at Dalhousie; experimental mathematicians before term was current.\(^2\)

1993-03 Moved to SFU to found Centre for Experimental & Constructive Maths www.cecm.sfu.ca (Shrum & CRC)

1995 Organic Mathematics Project: www.cecm.sfu.ca/organics

2004-09 JMB opens D-Drive (Dalhousie Distributed Research Institute and Virtual Environment) with Canada Research Chair funding

2004 PBB opens IRMACS (www.irmacs.sfu.ca) with CFI funds

2008 CARMA funded and opened as Univ. Priority Research Centre

2012 C-OPT founded and then departed

2013 CARMA renewed to 2018 or beyond? What to do?

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

1982  PBB & JMB ‘minor’ work on fast computation at Dalhousie; experimental mathematicians before term was current.²

1993-03  Moved to SFU to found Centre for Experimental & Constructive Maths www.cecm.sfu.ca (Shrum & CRC)

1995  Organic Mathematics Project: www.cecm.sfu.ca/organics

2004-09  JMB opens D-Drive (Dalhousie Distributed Research Institute and Virtual Environment) with Canada Research Chair funding

2004  PBB opens IRMACS (www.irmacs.sfu.ca) with CFI funds

2008  CARMA funded and opened as Univ. Priority Research Centre

2012  C-OPT founded and then departed

2013  CARMA renewed to 2018 or beyond? What to do?

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

1982 PBB & JMB ‘minor’ work on fast computation at Dalhousie;
experimental mathematicians before term was current.²

1993-03 Moved to SFU to found Centre for Experimental &
Constructive Maths www.cecm.sfu.ca (Shrum & CRC)

1995 Organic Mathematics Project: www.cecm.sfu.ca/organics

2004-09 JMB opens D-Drive (Dalhousie Distributed Research Institute
and Virtual Environment) with Canada Research Chair funding

2004 PBB opens IRMACS (www.irmacs.sfu.ca) with CFI funds

2008 CARMA funded and opened as Univ. Priority Research Centre

2012 C-OPT founded and then departed

2013 CARMA renewed to 2018 or beyond? What to do?

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

1982 PBB & JMB ‘minor’ work on fast computation at Dalhousie; experimental mathematicians before term was current.\(^2\)

1993-03 Moved to SFU to found Centre for Experimental & Constructive Maths www.cecm.sfu.ca (Shrum & CRC)

1995 Organic Mathematics Project: www.cecm.sfu.ca/organics

2004-09 JMB opens D-Drive (Dalhousie Distributed Research Institute and Virtual Environment) with Canada Research Chair funding

2004 PBB opens IRMACS (www.irmacs.sfu.ca) with CFI funds

2008 CARMA funded and opened as Univ. Priority Research Centre

2012 C-OPT founded and then departed

2013 CARMA renewed to 2018 or beyond? What to do?

II. CARMA’s Deep History

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

Experimentally-found modular fractal took 3 hrs to print

1982 PBB & JMB ‘minor’ work on fast computation at Dalhousie; experimental mathematicians before term was current.²

1993-03 Moved to SFU to found Centre for Experimental & Constructive Maths www.cecm.sfu.ca (Shrum & CRC)

1995 Organic Mathematics Project: www.cecm.sfu.ca/organics

2004-09 JMB opens D-Drive (Dalhousie Distributed Research Institute and Virtual Environment) with Canada Research Chair funding

2004 PBB opens IRMACS (www.irmacs.sfu.ca) with CFI funds

2008 CARMA funded and opened as Univ. Priority Research Centre

2012 C-OPT founded and then departed

2013 CARMA renewed to 2018 or beyond? What to do?

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

1982  PBB & JMB ‘minor’ work on fast computation at Dalhousie; experimental mathematicians before term was current.²

1993-03  Moved to SFU to found Centre for Experimental & Constructive Maths www.cecm.sfu.ca (Shrum & CRC)

1995  Organic Mathematics Project: www.cecm.sfu.ca/organics

2004-09  JMB opens D-Drive (Dalhousie Distributed Research Institute and Virtual Environment) with Canada Research Chair funding

2004  PBB opens IRMACS (www.irmacs.sfu.ca) with CFI funds

2008  CARMA funded and opened as Univ. Priority Research Centre

2012  C-OPT founded and then departed

2013  CARMA renewed to 2018 or beyond? What to do?

II. CARMA’s Deep History

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

Experimentally-found modular fractal took 3 hrs to print

1982 PBB & JMB ‘minor’ work on fast computation at Dalhousie; experimental mathematicians before term was current.\(^2\)

1993-03 Moved to SFU to found Centre for Experimental & Constructive Maths www.cecm.sfu.ca (Shrum & CRC)

1995 Organic Mathematics Project: www.cecm.sfu.ca/organics

2004-09 JMB opens D-Drive (Dalhousie Distributed Research Institute and Virtual Environment) with Canada Research Chair funding

2004 PBB opens IRMACS (www.irmacs.sfu.ca) with CFI funds

2008 CARMA funded and opened as Univ. Priority Research Centre

2012 C-OPT founded and then departed

2013 CARMA renewed to 2018 or beyond? What to do?

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

1982  PBB & JMB ‘minor’ work on fast computation at Dalhousie; experimental mathematicians before term was current.²

1993-03  Moved to SFU to found Centre for Experimental & Constructive Maths [www.cecm.sfu.ca](http://www.cecm.sfu.ca) (Shrum & CRC)

1995  Organic Mathematics Project: [www.cecm.sfu.ca/organics](http://www.cecm.sfu.ca/organics)

2004-09  JMB opens D-Drive ([Dalhousie Distributed Research Institute and Virtual Environment](http://www.cecm.sfu.ca)) with Canada Research Chair funding

2004  PBB opens IRMACS ([www.irmacs.sfu.ca](http://www.irmacs.sfu.ca)) with CFI funds

2008  CARMA funded and opened as Univ. Priority Research Centre

2012  C-OPT founded and then departed

2013  CARMA renewed to 2018 or beyond? What to do?

CARMA’s Structure and Membership

Currently 36 Members, 8 Associates, 7 Student Members:

- Steering Committee (George Willis Deputy Director)
- External Advisory Committee (IBM (G AJ chair), Melb, LBL)
- Scientific, Administrative and AGR Officers
- Members and Students from Newcastle and Associate Members from Everywhere:
  http://carma.newcastle.edu.au/people/

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

CARMA’s AMSI AGR and Inner Sanctum Rooms

J.M. Borwein  CARMA Retreat, 2013
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:**
  
  [Website](http://carma.newcastle.edu.au/people/)

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

---

**CARMA’s AMSI AGR and Inner Sanctum Rooms**

J.M. Borwein

CARMA Retreat, 2013
CARMA’s Structure and Membership

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:**

  http://carma.newcastle.edu.au/people/

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

**CARMA’s AMSI AGR and Inner Sanctum Rooms**
Scientific Activities  carma.newcastle.edu.au/carmaevents.shtml

- **Regular Colloquia and Seminar Series**
  - $\Sigma$Opt over AG, Group Theory
  - Int’l Webinar, Discrete Maths, Education, Applied Analysis and Number Theory, Student

- **AMSI AG**: 2013 New National Series  www.amsi.org.au
  - ANZIAM SIGMAopt AGR Seminar with UoSA and RMIT
  - 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 Iofe *Nonlinear analysis*
  - 2013 Honours courses (360hr) Seminars (150hr) Outreach (30hr)
• **Regular Colloquia and Seminar Series**
  - ΣOpt over AG, Group Theory
  - Int’l Webinar, Discrete Maths, Education, Applied Analysis and Number Theory, Student

  - ANZIAM SIGMAopt AGR Seminar with UoSA and RMIT
  - 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)
Scientific Activities carma.newcastle.edu.au/carmaevents.shtml

- **Regular Colloquia and Seminar Series**
  - $\Sigma$Opt over AG, Group Theory
  - Int’l Webinar, Discrete Maths, Education, Applied Analysis and Number Theory, Student

  - ANZIAM SIGMAopt AGR Seminar with UoSA and RMIT
  - 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)
• **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
Services include: [http://carma.newcastle.edu.au/resources/](http://carma.newcastle.edu.au/resources/)

### AGR

Grid-enabled connected-rooms for classes, seminars, meetings:

```c
int getRandomNumber()
{
    return 4;  // chosen by fair dice roll.
    // guaranteed to be random.
}
```

**V205** for dis-located collaboration;

**V206** for co-located collaboration.

### HPC

104 core MacPro x-grid Cluster; 144-core HTCondor cluster (64 GB) (RedHat); 12-core (24 hyperthreaded) Linux server (192 GB RAM) + access to NSW/National compute services.

### Web Services

  CECM → DDRIVE → CARMA Archie → Mosaic → Google
- Inverse symbolic calculator (ISC Plus)
  [http://isc.carma.newcastle.edu.au](http://isc.carma.newcastle.edu.au)
- BBP digit database [http://bbp.carma.newcastle.edu.au](http://bbp.carma.newcastle.edu.au)
- The Top Ten Numbers University Outreach
  [http://numbers.carma.newcastle.edu.au](http://numbers.carma.newcastle.edu.au)
**Services include:**

http://carma.newcastle.edu.au/resources/

**AGR**  **Grid-enabled connected-rooms** for classes, seminars, meetings:

```cpp
int getRandomNumber()
{
    return 4;  // chosen by fair dice roll.
    // guaranteed to be random.
}
```

**V205** for **dis-located** collaboration;

**V206** for **co-located** collaboration.

**HPC**  104 core **MacPro x-grid Cluster**; 144-core **HTCondor** cluster (64 GB) (RedHat); 12-core (24 hyperthreaded) Linux server (192 GB RAM) + access to NSW/National compute services.

**Web Services include:**

- **DocServer** http://docserver.carma.newcastle.edu.au:
  CECM → DDRIVE → CARMA Archie → Mosaic → Google

- **Inverse symbolic calculator (ISC Plus)**
  http://isc.carma.newcastle.edu.au

- **BBP digit database** http://bbp.carma.newcastle.edu.au

- **The Top Ten Numbers University Outreach**
  http://numbers.carma.newcastle.edu.au

- **Maths Hunter** http://ask.carma.newcastle.edu.au for School Outreach: **β-test**
Services include:  

**AGR**  
Grid-enabled connected-rooms for classes, seminars, meetings:  

```c
int getRandomNumber()
{
    return 4;  // chosen by fair dice roll.
    // guaranteed to be random.
}
```

V205 for dis-located collaboration;  
V206 for co-located collaboration.

**HPC**  
104 core MacPro x-grid Cluster; 144-core HTCondor cluster (64 GB) (RedHat); 12-core (24 hyperthreaded) Linux server (192 GB RAM) + access to NSW/National compute services.

**Web Services** include:  

- [DocServer](http://docserver.carma.newcastle.edu.au): CECM → DDRIVE → CARMA Archie → Mosaic → Google  
- Inverse symbolic calculator (ISC Plus)  
  [http://isc.carma.newcastle.edu.au](http://isc.carma.newcastle.edu.au)  
- [BBP digit database](http://bbp.carma.newcastle.edu.au)  
- The Top Ten Numbers University Outreach  
  [http://numbers.carma.newcastle.edu.au](http://numbers.carma.newcastle.edu.au)  
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.”

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 (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
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
12. Matt Tam awarded 2013 Vice-Chancellor’s Award for Outstanding Research Candidates.
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
Purer Research . . .

1. Number Theory Best results on irrationality of $\zeta$-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
Purer Research . . .

1. **Number Theory** Best results on irrationality of $\zeta$-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-through 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
Purer Research within CARMA

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)

Matt Tam’s movie:

http://carma.newcastle.edu.au/DRmethods/1PTQ.html
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)
"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
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
4. The AMSI Workshop on infectious disease modelling, Newcastle, 25–27th Sep 2013  
   - Internationally renowned keynote speakers  
   - Wouldn’t have been possible without CARMA funding
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

4. The AMSI Workshop on infectious disease modelling, Newcastle, 25–27th Sep 2013  
   • Internationally renowned keynote speakers  
   • Wouldn’t have been possible without CARMA funding
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

4. The AMSI Workshop on infectious disease modelling, Newcastle, 25–27th Sep 2013
   - Internationally renowned keynote speakers
   - Wouldn’t have been possible without CARMA funding

J.M. Borwein  CARMA Retreat, 2013
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

4. The AMSI Workshop on infectious disease modelling, Newcastle, 25–27th Sep 2013
   - Internationally renowned keynote speakers
   - Wouldn’t have been possible without CARMA funding
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)
Differential Equations at CARMA

\[ \frac{\partial^2 u}{\partial t^2} = c^2 \nabla^2 u \] (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)
Wave Processes

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—only possible because of initial funding and ongoing organizational support from CARMA.

Wave-induced break up of Antarctic sea ice (Meylan)
Wave Processes

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
   - only possible because of initial funding and ongoing organizational support from CARMA.

Wave-induced break up of Antarctic sea ice (Meylan)
Finite Element Methods (Lamichhane)

1. **Finite Element Method or FEM** is the most important method for numerical solution of differential equations.

2. For example, almost every aspect of modern structural engineering, fluid dynamics, etc rely on it.

Heat generated by friction simulated by FEM (Bishnu)
Finite Element Methods

1. **Finite Element Method or FEM** is the most important method for numerical solution of differential equations.

2. For example, almost every aspect of modern structural engineering, fluid dynamics, etc rely on it.

Heat generated by friction simulated by FEM (Bishnu)
Other ‘applied’ Collaborations within UofN (JMB)

1. **Radiology** (Borwein-Tam) Fast Padé Transforms for spectral analysis in *functional MRI*
   - paper in process with Carolyn Mumford and Saadallah Ramadan

2. **Chemistry** (Borwein-Sims-Tam) Structure of ionic liquids
   - with Rob Atkins and Alister Page (early stage)

3. **Fine Arts** (Borwein-Aragon) Music and Mathematics
   - with Richard Vella and Jon Drummond

4. **Students in other schools** & sporadic consulting

---

Oct 2012 Concert “Music and Mathematics”, Harold Lobb Hall
Other ‘applied’ Collaborations within UofN (JMB)

1. **Radiology** (Borwein-Tam) Fast Padé Transforms for spectral analysis in *functional MRI*
   - paper in process with Carolyn Mumford and Saadallah Ramadan

2. **Chemistry** (Borwein-Sims-Tam) Structure of ionic liquids
   - with Rob Atkins and Alister Page (early stage)

3. **Fine Arts** (Borwein-Aragon) Music and Mathematics
   - with Richard Vella and Jon Drummond

4. **Students in other schools & sporadic consulting**

---

Oct 2012 Concert “Music and Mathematics”, Harold Lobb Hall
Other ‘applied’ Collaborations within UofN (JMB)

1. **Radiology** (Borwein-Tam) Fast Padé Transforms for spectral analysis in *functional MRI*
   - paper in process with Carolyn Mumford and Saadallah Ramadan

2. **Chemistry** (Borwein-Sims-Tam) Structure of ionic liquids
   - with Rob Atkins and Alister Page (early stage)

3. **Fine Arts** (Borwein-Aragon) Music and Mathematics
   - with Richard Vella and Jon Drummond

4. Students in other schools & sporadic consulting

Oct 2012 Concert “Music and Mathematics”, Harold Lobb Hall
Our newest formal research group:
http://numeric.carma.newcastle.edu.au/
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
  - More authentic mathematical experiences in teacher training
  - Enhanced professional development opportunities for teachers

People: Judy-anne Osborn, Peter Howley, Kathryn Holmes, Elena Prieto, Malcolm Roberts, Andrew Kepert, Jonathan Borwein, John O’Connor, Jenny Gore

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**: $2.2 million 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
  - More authentic mathematical experiences in teacher training
  - Enhanced professional development opportunities for teachers

People: Judy-anne Osborn, Peter Howley, Kathryn Holmes, Elena Prieto, Malcolm Roberts, Andrew Kepert, Jonathan Borwein, John O’Connor, Jenny Gore


J.M. Borwein  CARMA Retreat, 2013
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: $2.2 million 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
  - More authentic mathematical experiences in teacher training
  - Enhanced professional development opportunities for teachers

People: Judy-anne Osborn, Peter Howley, Kathryn Holmes, Elena Prieto, Malcolm Roberts, Andrew Kepert, Jonathan Borwein, John O’Connor, Jenny Gore

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
  - More authentic mathematical experiences in teacher training
  - Enhanced professional development opportunities for teachers

People: Judy-anne Osborn, Peter Howley, Kathryn Holmes, Elena Prieto, Malcolm Roberts, Andrew Kepert, Jonathan Borwein, John O’Connor, Jenny Gore

CARMA advancing the next generation through:

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

- **Maths and Engineering Competitions and Challenges**

- **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.
  Judy-anne Osborn, Brailey Sims, Elena Prieto, Bailey Sims

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

- **Relationships and community-building**
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
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
Wadim Zudilin is a superb experimental mathematician

JMB, Sims and their students have become expert at data mining and at discovering visual theorems

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

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

See the Stoneham movie at http://carma.newcastle.edu.au/videos/S23_b4.html showing how non random the number drawn above right is.
Wadim Zudilin is a superb experimental mathematician.

JMB, Sims and their students have become expert at data mining and at discovering visual theorems:
- using dynamic geometry software, animations, computer algebra, etc.

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

See the Stoneham movie at
showing how non random the number drawn above right is.
Visualisation at CARMA

- Wadim Zudilin is a superb experimental mathematician
- JMB, Sims and their students have become expert at data mining and at discovering visual theorems
  - using dynamic geometry software, animations, computer algebra, etc.

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

- See the Stoneham movie at http://carma.newcastle.edu.au/videos/S23_b4.html showing how non random the number drawn above right is.
Visualisation at CARMA

This page contains a collection of visualisation-related pages, sites and projects at CARMA.

1. **Watts**
   - Investigations of tools for representing floating point numbers as planar or three-dimensional walks and for quantitatively measuring their "randomness".
   - [Contact](#)

2. ***Numbers***
   - Scientific constants battle for supremacy: who will win?
   - [Contact](#)

3. **EVIMS**
   - A 3-day workshop, held in November 2012, on the effective use of visualisation in mathematics, physics, and statistics from the perspectives of education, research, and outreach.
   - [Contact](#)

4. **Symbolic Convex Analysis**
   - A book discussing various classes of sets and their characteristics, treating convex functions in both Euclidean and Banach spaces.
   - [Contact](#)

5. **Iterative Projection Methods**
   - Iterative projection methods form the basis of a number of algorithms used to solve optimisation problems.
   - [Contact](#)

6. **Polytope Diagrams**
   - Methods and images relating to our glasses-free 3-D screen.
   - [Contact](#)

7. **Miscellaneous**
   - Miscellaneous images from our research.
   - [Contact](#)

8. **Other**
   - Is something missing? Let us know.
   - [Contact](#)

**Please:**

1. Remember there is seed funding and help for all good projects: ([http://carma.newcastle.edu.au/reads/](http://carma.newcastle.edu.au/reads/))

2. Bookmark the Home page

3. Regularly monitor Events and make sure they are advertised

4. Report Issues to David Allingham and Roslyn Hickson

5. Suggest Additions and Enhancements

---

J.M. Borwein  
CARMA Retreat, 2013
Please:

1. Remember there is seed funding and help for all good projects: (http://carma.newcastle.edu.au/reads/)

2. Bookmark the Home page

3. Regularly monitor Events and make sure they are advertised

4. Report Issues to David Allingham and Roslyn Hickson

5. Suggest Additions and Enhancements
Visualisation at CARMA

This page contains a collection of visualisation-related pages, sites and projects at CARMA.

1. Wells
   Investigations of tools for representing floating point numbers as planar or three-dimensional walks and for quantitatively measuring their "randomness".

2. "Numbers"
   Scientific constants battle for supremacy: who will win?

3. EVIMS
   A 3-day workshop, held in November 2012, on the effective use of visualisation in mathematics, physics, and statistics from the perspectives of education, research, and outreach.

4. Symbolic Convex Analysis
   A book discussing various classes and their characteristics, treating convex functions in both Euclidean and Banach spaces.

5. Iterative Projection Methods
   Iterative projection methods form the basis of a number of algorithms used to solve optimisation problems.

6. Peaucellier Envelop
   Methods and images relating to our glasses-free 3-D screen.

7. Miscellaneous
   Miscellaneous images from our research.

8. Other
   Is something missing? Let us know.

Please:

1. Remember there is seed funding and help for all good projects: (http://carma.newcastle.edu.au/reads/)
2. Bookmark the Home page
3. Regularly monitor Events and make sure they are advertised
4. Report Issues to David Allingham and Roslyn Hickson
5. Suggest Additions and Enhancements
We offer a variety of services to our members and their students (and to many others)

- Some are forced upon us by problems with UofN Academic Computing support
- Taking PRC money from research
- Relying on significant subsidy from the director’s other funds

See details at:
Member Services

- We offer a variety of services to our members and their students (and to many others)
  - Some are forced upon us by problems with UofN Academic Computing support
  - Taking PRC money from research
  - Relying on significant subsidy from the director’s other funds

See details at:
Conclusions

- 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

We are having fun

2012 CARMA shirts (Ballarat AMS)

Happy pi day!!
Conclusions

• 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
Conclusions

- 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
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
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.

**Related Material**

1. **Feasibility Methods: Divide and Concur**

2. **Experimental Mathematics: for Everything**

3. **Pi Day:**

4. **Walking on Numbers: a Viral Success**

5. **Lattice Sums: Then and Now**

6. **The Director’s Blogs**
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.

**Related Material**

1. **Feasibility Methods: Divide and Concur**

2. **Experimental Mathematics: for Everything**

3. **Pi Day:**

4. **Walking on Numbers: a Viral Success**

5. **Lattice Sums: Then and Now**

6. **The Director’s Blogs**
Not bad for the first five years

Given real support from P/VC for:

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

Related Material

1. Feasibility Methods: Divide and Concur
   http://carma.newcastle.edu.au/DRmethods/

2. Experimental Mathematics: for Everything
   http://www.carma.newcastle.edu.au/expmaths/

3. Pi Day:

4. Walking on Numbers: a Viral Success
   http://walks.carma.newcastle.edu.au/

5. Lattice Sums: Then and Now

6. The Director’s Blogs

2010: Communication is not yet always perfect

J.M. Borwein  CARMA Retreat, 2013