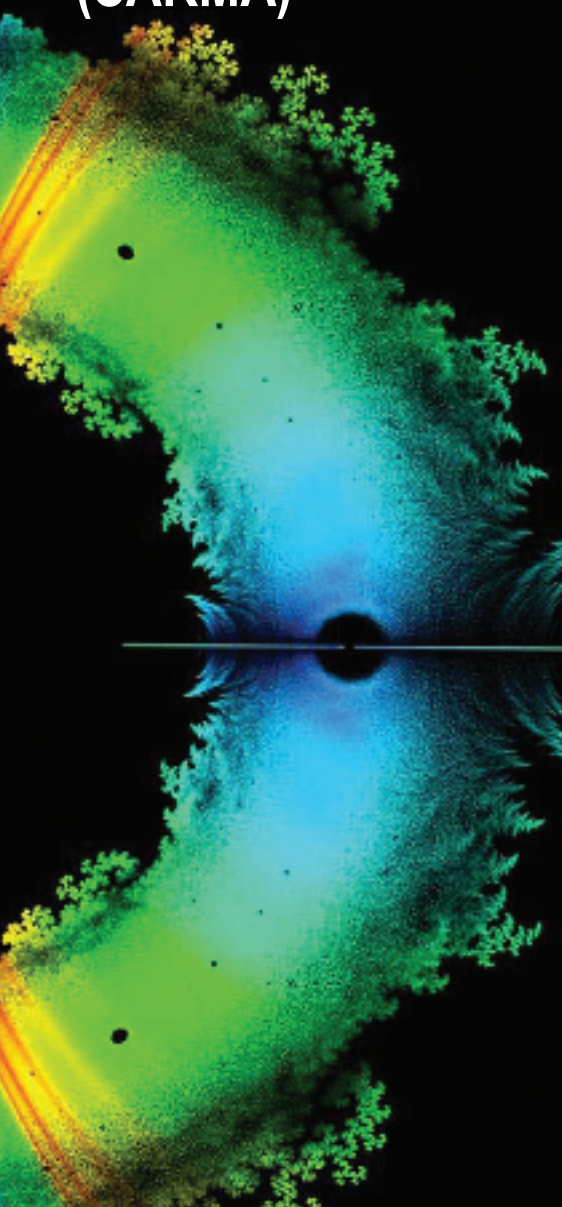


# COMPUTER ASSISTED RESEARCH MATHEMATICS AND ITS APPLICATIONS (CARMA)



## OVERVIEW

CARMA forms the base for a vibrant cross-university and intra-university Priority Research Centre. There is no corresponding group in Australia and there are very few internationally.

Mathematics as “the language of high technology” underpins all facets of modern life and current Information and Communication Technology (ICT). Yet no research centre exists focusing on the implications of developments in ICT, present and future, for the practice of research mathematics. CARMA partly fills this gap through the exploitation and development of techniques and tools for computer-assisted discovery and disciplined data-mining including mathematical visualisation.

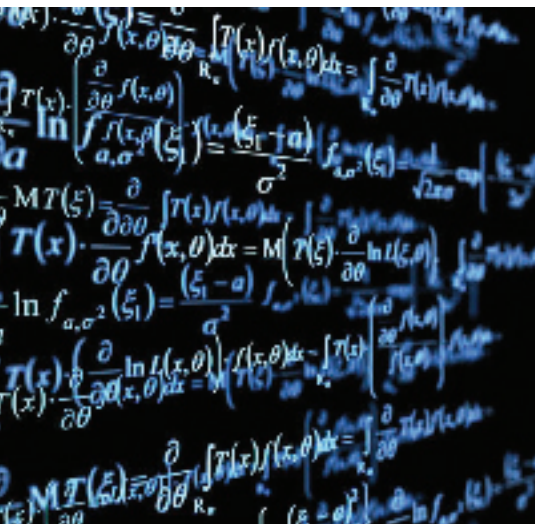
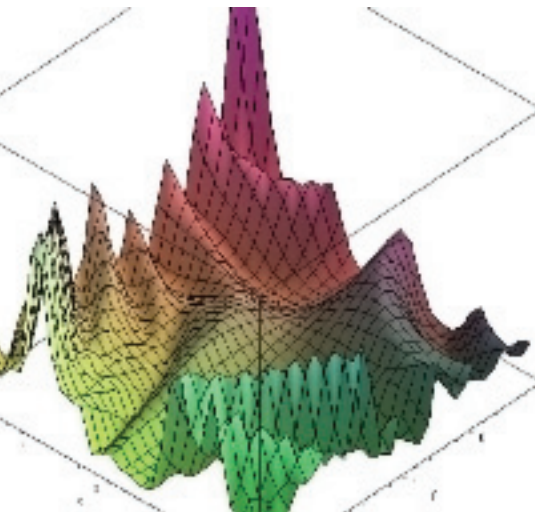
Advanced mathematical computation is equally essential to the solution of real-world problems; sophisticated mathematics is core to software used by decision-makers, engineers, scientists, managers, and those who design, plan and control the products and systems key to present day life.

## OBJECTIVES

- To perform research and development 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).
- To perform research and development of mathematics underlying computer-based decision support systems, particularly in automation and optimization of scheduling, planning and design activities, and to undertake mathematical modelling of such activities.
- To promote and advise on the use of appropriate tools (hardware, software, databases, learning object repositories, mathematical knowledge management, collaborative technology) in academia, education and industry.
- To make the University of Newcastle a world-leading institution for Computer Assisted Research Mathematics and its Applications.

## GROUP MEMBERS

Dr Brian Alspach  
Dr Ian Benn  
Prof Natasha Boland  
Laureate Prof Jonathan Borwein  
Prof Richard Brent  
Prof Roger Eggleton  
Dr Murray Elder  
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## EXAMPLES OF CURRENT PROJECTS

**Analysis** - Classical, harmonic, non-linear, convex analysis and variational analysis. Metric geometry and fixed point theory.

**Continuous Optimization** - Maximum entropy optimization, wavelet analysis and image reconstruction methods.

**Discrete Optimization** - Accurate scheduling for open-pit mining, modelling effects of uncertainty in geological estimates on the extraction schedule.

**Simple Topological Groups** - Understanding simple totally disconnected locally compact groups.

**Arithmetic Hypergeometric Series**

## RESEARCH OUTCOMES

- Current best results on irrationality of Zeta-function values obtained.
- Leading edge results on structure of maximal monotone operators.
- Lower cost airline schedules that are more robust to operational disruptions.
- Optimized delivery of radiotherapy (IMRT) treatment for cancer.
- Largest accurate geological models for mineral extraction.
- Consultation with gaming industry, real-world network design and scheduling.

## RESEARCH TOPICS

**Computational Analysis and Number Theory:** computer-assisted study of links between analysis, number theory, knot theory and mathematical physics. Development of mathematical data-mining tools.

**Discrete Mathematics:** all aspects of graph theory with emphasis on algebraic graph theory and ties to design theory.

**Linear and Nonlinear Analysis** including: convexity; variational methods; fixed point theory; Banach space geometry; frames and wavelet analysis. Applications to dynamical systems, control, optimization, and image or signal reconstruction.

**Optimization and Simulation:** models and algorithms for optimization and solution of large-scale problems using constraint programming and meta-heuristics.

**Harmonic Analysis:** Fourier analysis, wavelets, time-frequency analysis, sampling and signal processing applications; singular integrals and frames; Clifford analysis and applications to hypercomplex signal processing.

**Topological Groups:** structure and automorphisms of totally disconnected groups; links to harmonic analysis, geometry, number theory and discrete maths.

**Number Theory:** Arithmetic, algebraic and combinatorial properties of solutions of differential and difference equations; Diophantine analysis.

## RESEARCH SUPPORT

ARC and NSERC Discovery grants, ARC Linkage International grants, ARC Linkage grants with BHP-Billiton, CTI Pty Ltd, MITACS, NIST.

Student/Research Assistant support from DSTO MOD, International Mathematical Union, MapleSoft, MathResources, and Sun Microsystems.

## EXTERNAL COLLABORATORS

BHP-Billiton; Constraint Technologies International Pty Ltd; Canadian National Centre of Excellence for Mathematics of Information Technology and Complex Systems (MITACS); CSIRO Energy Technology; Mater Hospital, Radiation Oncology Department; Hunter New England Area Health Service, Innovation and Reform Unit; Hunter Valley Coal Chain Logistics Team; MapleSoft Inc; Mathematical Association of America; International Mathematical Union; MathResources Inc; National Institute of Standards and Technology; Sun Microsystems.

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