# *Dave Broomhead's 60th Birthday*

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# Dave Broomhead's 60th Birthday

**On 15–16 November 2010**, friends and colleagues from all walks of Dave Broomhead's wide research career gathered at a meeting in honour of his 60th birthday.

Dave is Professor of Applied Mathematics at the University of Manchester. Following a DPhil in theoretical chemistry, he held a NATO Postdoctoral Fellowship in the Department of Physics at the University of Kyoto. Dave then worked as a Senior Principal Scientific Officer at the Royal Signals and Radar Establishment (RSRE) at Malvern (latterly QinetiQ), before taking up a chair in Manchester.

Since the early 1980s, one of his main interests has been the development of methods for time series analysis and nonlinear signal processing using techniques from the theory of nonlinear dynamical systems. He has done interdisciplinary research through application of these ideas to a wide range of areas: mathematics, physics, signal processing and electrical engineering whilst in Malvern, and new collaborations in life science and systems biology since moving to Manchester.

Dave is currently director of the Centre for Interdisciplinary Computational and Dynamical Analysis (CICADA) who hosted this meeting. Dave is also a Fellow of the Institute and Editor of this publication.


## Elastic instabilities lead to novel material properties

**Tom Mullin (Manchester)** met Dave at Oxford in a cupboard. As with all the speakers, he benefitted greatly from discussions with him. He spoke about how elastomeric cellular solids with holes arranged on a square lattice respond non-uniformly to uniaxial compression. These phenomena, discovered at the millimetre scale, can be applied to the nanometre scale to create tuneable, scaleable auxetic crystals.

## Where do instabilities go?

**George Rowlands (Warwick)** was Dave's post-doctoral supervisor. He spoke about fusion reactors and the transition of plasma from an unstable state to two possible final states. By using Lagrangian methods some clues have been obtained about the transfer process, to ensure the plasma organises itself to go to the 'good' state.

## Data, neurons and what happens next

**Richard Clement** was a colleague of Dave's in Malvern. He presented his findings from a collaboration on applying dynamical systems analysis to the oculomotor system, with the help of spinning tops and optical illusions. The talk culminated with an argument that the visual objects which brains are capable of attending to depends on the type of maths of which they are capable.

## Mathematics and biology – an overview

**Douglas Kell (Manchester, BBSRC)** and Dave enjoyed an extremely fruitful collaboration together, leading to many research papers and funding grants. Doug summarised a few strands of activity that show not only what mathematics can bring to biology but also what biology can bring to mathematics.

## Speech analysis and synthesis based on dynamic modes

**Steve McLaughlin (Edinburgh)** showed that speech can be understood as a superposition of modes associated with physiological aspects of the vocal system such as vocal chords and lips. By using a framework based on dynamic mode predictors and filters, adapted using gradient-based techniques, a high-resolution representation of the speech signal can be obtained.

## Another view from the Malverns – the third dimension

**John McWhirter CMath FIMA (Cardiff)** is another colleague of Dave's from the signal processing group in Malvern, now working in Cardiff. He presented his recent work on the general Kogbetliantz algorithm for polynomial SVD and its applications in underwater acoustics or multichannel allpass filters for power-line communications.

## Time stealing: An adventure in Tropical land

**Marianne Johnson (Manchester)** is a member of CICADA, who presented an entertaining analogy between 'Tropical geometry land' and 'Alice's Adventures in Wonderland' from the book of Lewis Carroll. In particular, by applying tropical geometry, one can model and optimise the use of asynchronous processes in the design of digital hardware. Or, as the Duchess said, 'If everybody minded their own business, the world would go around a deal faster than it does.'

## Fractal Skeletons: The universality in death by starvation

**Celso Grebogi (Aberdeen)** was inspired by reading Dave's work in the 1980s, though he didn't meet him until the 1990s. He showed that, if the dynamics of active particles in flows – such as growing populations of plankton in the oceans – is chaotic, then necessarily the concentration of these particles have the observed fractal filamentary structures. These skeletons yield an unusual singularly enhanced productivity that could explain the paradoxical coexistence of such a large number of plankton species.

## A mathematician's view of circadian rhythms

**David Rand (Warwick)** is a long-time collaborator of Dave's. He summarised his view of what are the most important questions about circadian rhythms at the single cell level, motivated by recent experimental results and mathematical ideas.

## Ants and slime mould solve the Towers of Hanoi

**David Sumpter (Upsalla).** In 2004, Dave – David's then PhD supervisor – suggested that one could test whether ants could solve the famous Towers of Hanoi problem by mapping the problem onto a graph. Indeed, both ants and acellular slime mould can solve the problem. Moreover, by linearly reinforcing the edges of a graph, a mathematical model predicts that 'simple' organisms are guaranteed to find the shortest path through a graph.

David dedicated the following paper to Dave on the occasion of his 60th birthday: Reid, C. R., Sumpter, D. J. T. and Beekman, M. Optimization in a Natural System: Argentine Ants Solve the Towers of Hanoi, *Journal of Experimental Biology*.

## Data reduction: A view from the Rockies

**Michael Kirby (Colorado)** presented some geometric approaches for analyzing data cubes. His application – the set of all of English chess grandmaster Michael Adams' games – led to a dataset of around chess 300,000 boards. By drawing ideas from geometry to the encoding of such massive data-sets, Michael illustrated how interesting information can be extracted.❑

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