

Centre for Complex Systems

The Centre for Complex Systems (CCS) plays a major role in drawing together the disparate complex systems science components of the College of Science at the Australian National University.

The aims of the Centre are:

- to provide a framework for bringing researchers together and stimulating interaction and synergy between them;
- to promote innovative, interdisciplinary research through seminars and topical workshops;
- to foster graduate education and research through summer schools.

The CCS was formed from the Centre for Theoretical Physics in late 2001, and continues its outreach activities while broadening its scope to the application of the powerful tools of modern theoretical physics and applied mathematics to problems ranging from the physical to the biological sciences, and even beyond to complex systems with a social dimension. A key feature in these systems is a large number of individual units interacting collectively and the emphasis is on the emergent behaviour beyond the elementary laws of interaction. The unifying theoretical and mathematical tools include statistical mechanics, many body theory and nonlinear dynamics, as well as numerical simulation.

The CCS initiated and hosts the *ARC Complex Open Systems Research Network* (COSNet) which was funded for five years from late 2004. The Centre now administers the Australian National University's central contribution to COSNet. Administrative support for the Centre, formerly provided by the Department of Theoretical Physics, is now also provided through COSNet.

Summer Schools

With two Summer Schools having taken place at the beginning and the end of 2004, no Summer School was held in 2005. In 2005 the Centre assisted with preparation for the 19th Canberra International Physics Summer School on Turbulence and Coherent Structures in Fluids, Plasma and Granular Flows, 16-20 January 2006, convened by Dr Michael Shats.

CCS Seminars

Professor Robert MacKay, FRS, University of Warwick, UK

Ergodic Pumping: A Mechanism to Drive Biomolecular Conformation Change
(Joint Seminar of the CCS and the ARC Nanotechnology Network)

Professor Robert MacKay, FRS, University of Warwick, UK

Examples of How Mathematics Can be Useful (Even Essential) for Understanding Complex Systems (Closed and Open)

Professor Vasily Yu Belashov, Kazan State Power Engineering University, Russia
Dynamics of Multidimensional Nonlinear Wave Structures of Soliton and Vortex Types in Dispersive Media

Dr Glenn Kentwell, Global Rates and Structuring, Citigroup
So You Want to Become a Wall Street Rocket Scientist?

Professor Dan Dubin, University of California at San Diego, USA
Equilibrium and Dynamics of Vortices in 2D Euler Flow

Adjunct Professor Robert Robson, Australian National University
Entropy Production and the Second Law of Thermodynamics: A General Review and Applications in Low-temperature Plasma Physics

Dr Antoinette Tordesillas, University of Melbourne
A Micromechanical Continuum Theory for Densely Packed Granular Media

Professor Sadruddin Benkadda, CNRS – Université de Provence, Marseille, France
Nusselt Number Scaling in Plasma and Fluid Turbulence

Professor David J. Hill, Federation Fellow, Australian National University
Complex Networks: Dynamics, Optimization and Control

Dr David Liley, Swinburne University of Technology, Melbourne
Modelling the Effects of Anaesthesia on Human-brain Electrical Activity

Staff

Coordinator

Professor Robert L. Dewar, FAA

Deputy Coordinator

Professor Murray T. Batchelor, FAIP, FAustMS, FInstP

Chair of Board

Professor Denis Evans, FAA

The Centre for the Mind

The Centre for the Mind is a joint venture of The Australian National University and the University of Sydney. News Limited provided the foundation sponsorship. Nelson Mandela is the Millennium Fellow and Dr Oliver Sacks the Foundation Fellow. The Centre is an internationally recognised brand. It is mentored, through its Board and Advisory Council by Australia's most influential and creative minds, including Phillip Adams, Nobel Prize laureate Peter Doherty and film director/producer Baz Luhrmann. It has received worldwide media focus, including dedicated television and radio profiles; documentaries by the British BBC; the American ABC and NBC; the Tokyo Broadcasting System; and the Australian ABC. It has also featured in the New York Times; the Times of London; many other leading international media publications, and the esteemed scientific journals Nature and Science. The Centre's website (www.centreforthemind.com) provides a comprehensive overview of the Centre and its achievements.

The Centre's research focuses on creativity and human potential, with a view to benefiting society. The Centre's research on revealing the mind's hidden skills using transcranial magnetic stimulation was published in the Journal of Integrative Neuroscience. This work was the cover story on New Scientist in April 2004 and the Canberra Times "Panorama" in March 2005, and was reported in major features by the New York Times, The Times of London, Der Spiegel, The Australian Magazine, ABCTV USA, Discovery (NBC TV Documentary), and many others. A new area of research was initiated about nonconscious problem solving (the "let me sleep on it" phenomenon) with a paper in Psychological Science. In addition, the Centre formulated an information theoretic approach to evaluating a person's creativity – the Creativity Quotient, with a paper in the Creativity Research Journal – and advanced a theory on concept formation. Finally, the Centre completed a study on the nonconscious evaluation of angry faces using transcranial magnetic stimulation. A MindLab has been established for brain/mind investigations jointly with the Research School of Biological Sciences.

Professor Allan Snyder opened the Snyder Theatre for MindChamps in Singapore, named in his honour. He also outlined a potential treatment for autism at the prestigious Nancie Lurie Marks Family Foundation in Boston. Professor Snyder was singled out in the Fairfax press as an '*Australian who matters to the world*'. He also flew to Brisbane to collaborate with Professor Jack Pettigrew and gave an internationally publicised Graduation Address at Canberra Boys Grammar.

The Centre for the Mind ran a successful corporate workshop for Telstra on creativity and the champion mindset, based on its novel scientific measure for creativity. The Centre also received strong endorsement in the Committee's Report in its first five-year review, undertaken in late 2004.

The Centre again received global media attention, including worldwide and Australian television features, extended features in popular press and documentaries devoted to the Centre's research, including:

- The Guardian (UK) "*A Genius Explains*"
- The Australian Financial Review
- Sydney Morning Herald & The Age "*Fifty Australians Who Matter to the World*"
- Scientific America's Mind issue
- The Sydney Morning Herald's – The Sydney Magazine
- New Scientist Creativity special issue
- Panorama (Canberra Times) cover story
- Discovery Channel documentary "*Savants*"
- The Herald (UK) newspaper
- Russian Newsweek

Staff (ANU and University of Sydney)

Professor and Head of Centre

Allan Snyder FRS FAA FTSE

Professor and Associate Director

(Douglas) John Mitchell

Postdoctoral Fellows

Magali Batty (to August)

Rasa Rusekaite (from September)

Visiting Fellows

Terry Bossomaier

Research Associates

Homi Bahramali

Research Assistants

Michael Harre

Toby Hawker

Projects

John McDougall

Web Development and Event Management (Sydney Administration)

Sylvia Bembo

Departmental Administrator

Edwina Fingleton-Smith

The Cooperative Research Centre for Functional Communication Surfaces

The Cooperative Research Centre for Functional Communication Surfaces (CRC SmartPrint) began operations on 1 July 2001, following funding from the Australian Government. Principal academic partners are located in Chemical Engineering, Monash University, Applied Mathematics, RSPHysSE, and the CSIRO Divisions of Forestry and Forest Products and Molecular Sciences (Clayton, Victoria). Industrial partners include AMCOR Packaging (Australia) Pty Ltd, Carter Holt Harvey Tissue Pty Ltd, Norske Skog Paper Mills (Australia) Ltd, Note Printing Australia Ltd and PaperlinX Pty Ltd (Australian Paper).

The brief of the CRC SmartPrint is to advance Australia's printing and packaging technology and expertise, with particular emphasis on advanced papers and polymeric materials (including banknotes), smart packaging indicators, improved recycling of paper and enhancement of cardboard packaging. Though these areas sound boring, they are major industries in the Western world, and even minor incremental improvements in these areas are of major benefit to consumers and producers. A number of research areas are covered by the CRC SmartPrint partners, including extensional rheology, surface chemistry and energy, polymer rheology, colloid science, three-dimensional imaging of microstructures, and print quality analyses. The ANU node is focussed on providing accurate microstructural data of relevant materials, analysing the surface physics of imbibition of, for example, inks into papers, developing accurate mechanical models and measures of mechanical properties of various printing substrates. A novel feature of our contribution is the insistence that Applied Mathematics focus on the fundamental aspects of research. This has been welcomed by our industrial partners, who recognise the need for further fundamental understanding of many processes associated with printing and paper and board production. The industry remains largely empirical, despite its enormous economic importance, and the group in Applied Mathematics is ideally equipped to investigate a number of important and interesting issues from our fundamental research perspective. While the issues are industrial in motivation, a number of fascinating problems that call on our skills are being tackled.

The work is experimental, theoretical and computational, in keeping with the philosophy of Applied Mathematics. Projects are making extensive use of the new X-ray CT machine, the Surface Forces Apparatus, Atomic Force Microscope and Ellipsometer. In the third complete year of the Centre, the ANU program continued work on four fundamentally based projects and a fifth strategic project aimed at addressing specific industry problems. The highlights of research from the four fundamental projects that have commenced include:

- development of three dimensional image enhancement techniques to remove blurring and distinguish material boundaries;
- image skeletonisation and generation of network equivalents of paper and coatings have been initiated;

- continued development of software to analyse structural, mechanical and transport properties directly from 3D digitised images of complex materials;
- development of a new dynamic method to measure fluid penetration into paper sheets using X-ray radiography (time resolved digital radiography). Currently, software for analysing the data (e.g. saturation profiles, density correlations) is being developed;
- a compressional rheology rig suitable for use with X-ray CT has been built. Customised software has been written to control the pressure within the rig and measure the loss of fluid from the fibre cake;
- a dynamic model for wetting fluid penetration (imbibition) has been developed based on a physically realistic and mathematically rigorous treatment of the complex dynamics of wetting front displacements.

CRC Staff

Program Manager

Dr Mark Knackstedt

Program Leaders

Dr Vince Craig

Dr Tim Senden

Researchers

Professor Stephen Hyde

Dr Ajay Limaye

Dr Arthur Sakellariou

Dr Adrian Sheppard

Dr Rob Sok

Dr Nobuo Maeda

Students

Mr Drew Evans

Mr Ray Roberts

Technical Staff

Mr Anthony Hyde

Mr Tim Sawkins

CRC Administrator

Ms Jan James