# Preface

This book arose from a summer school held in Canberra in December 2008, primarily funded by the Australian Research Council's Complex Open Systems Research Network (COSNet), which is hosted by The Australian National University (ANU) Centre for Complex Systems. The summer school was the 22nd Physics Summer School organised under the auspices of the Centre for Complex Systems and its predecessors,[1] and was also generously supported by the Asia-Pacific Center for Theoretical Physics.

COSNet started in 2004 with the vision statement:

> Complexity is the common frontier in the physical, biological and social sciences. This Network will link specialists in all three sciences through five generic conceptual and mathematical theme activities. It will promote research into how subsystems self-organise into new emergent structures when assembled into an open, non-equilibrium system. Outcomes will include new technologies and software tools and deeper understanding of fundamental questions in science. An essential function of the network will be introducing researchers and end users to new tools and broadening the horizons of graduate students.

---

[1] The summer schools were started by the ANU Department of Theoretical Physics in 1988, and were continued from 1994 by the Centre for Theoretical Physics at ANU (initially with the aid of seed funding from the ARC as a pilot for a National Institute for Theoretical Physics) until it became the ANU Centre for Complex Systems in 2001, which has continued this tradition as part of the COSNet vision.

COMPLEX PHYSICAL, BIOPHYSICAL AND ECONOPHYSICAL SYSTEMS - Proceedings of the 22nd Canberra International Physics Summer School

http://www.worldscibooks.com/physics/7340.html

The chapters of this book have been written by the Summer School lecturers, including those in computer laboratory sessions introducing software tools. The book presents up-to-date discussions of new theoretical approaches and tools (in particular from *statistical and nonlinear physics*)—fractional diffusion, dynamical systems analysis, entropy approaches, network analysis, agent-based modelling—and is unique in the scope of its coverage of applications of complex systems science:

- Extraterrestrial complex systems science—astrophysical, solar and space plasmas;
- Earth system science—from the technicalities of global warming to the Gaia big picture;
- Living and man-made systems–financial systems, genomics, brain dynamics, social networks, use of chaos theory in technologies.

All chapters were peer reviewed, and indexed using a common lexicon of keywords, in particular ones bringing out the generic features of complex systems, such as the following properties: Complex systems

- exhibit *emergence*: some properties present at system level are not present at a lower level, e.g. a cell is alive, but is made of inanimate elements;
- are *open*: energy and information are constantly being imported and exported across system boundaries;
- have a *history*: the history cannot be ignored, even a small change in circumstances can lead to large deviations in the future;
- can *adapt*: in response to external or internal changes, systems can self-organise without breaking;
- are *not completely predictable*: when a system is adaptive, unexpected behaviours can emerge—prediction becomes statistical expectation;
- are *multi-scale and hierarchical*: system size and structure scale are over several orders of magnitude and distinct properties and functions are associated with different scales—dynamics can propagate through scales and exhibit avalanches and cascade effects;
- are *not simply ordered*: there is no compact and concise way to encode the whole information contained in the system;
- have *multiple (meta) (stable) states*: small perturbations lead to recovery, larger ones can lead to radical changes of properties—dynamics do not average simply.

COMPLEX PHYSICAL, BIOPHYSICAL AND ECONOPHYSICAL SYSTEMS - Proceedings of the 22nd Canberra International Physics Summer School

The editors wholeheartedly thank the chapter authors and peer reviewers for making this book possible. We also thank all the summer school participants, the sponsors and the support people, in particular Mr Daniel Chan, COSNet Manager for assistance with all aspects of the organisation, and Ms Fanny Lemaitre-Detering for help with graphics design.

Robert L. Dewar, organiser, editor, and Convenor of COSNet
Frank Detering, organiser and editor

Canberra, October 2009

COMPLEX PHYSICAL, BIOPHYSICAL AND ECONOPHYSICAL SYSTEMS - Proceedings of the 22nd Canberra International Physics Summer School