Cyber-sociology

The Complexity of Cooperation: Agent-Based Models of Competition and Collaboration
by Robert Axelrod
Princeton University Press: 1997. Pp. 232. $49.50, £35 (hbk), $18.95, £14.95 (pbk)

Karl Sigmund and Martin A. Nowak

When Robert Axelrod's book *The Evolution of Cooperation* appeared in 1984, it turned into an instant classic, and deservedly so. Its influence reached far beyond political science, experimental psychology and evolutionary biology; by now, a large public has become familiar with its clear and soberly optimistic message. Richard Dawkins has hailed it as "one of the two books that have excited me most" (the other was one of his own).

After such a triumph, what do you do for an encore? It must have been a daunting task to write a sequel. Axelrod decided upon a totally different format. *The Evolution of Cooperation* was tightly focused on one model (a population of individuals interacting in repeated 'prisoner's dilemma' games) and explored one issue only, namely reciprocal aid. *The Complexity of Cooperation*, on the other hand, is a loose collection of a handful of papers published in diverse journals and dealing with sundry aspects of exploring new strategies, converging on norms, building coalitions or disseminating cultural traits. Each paper is preceded by a short introduction.

The common thread running through all these chapters is the so-called 'bottom-up approach', which is by now quite orthodox: it consists in reducing the interaction to a simple game, devising programs for playing it, and running computer simulations of populations of agents guided by these programs.

Axelrod explains that the "complexity" in the title has a double meaning: the interactions that he examines are complicated, and the techniques he uses are those of complex adaptive systems theory in the sense propagated by the Santa Fe Institute and its aficionados.

Despite the title, one will not find lots of complexity in this book. The hype surrounding the 'edge of chaos' and 'self-organized criticality' is totally eschewed, and the simplicity of the models is occasionally breathtaking.

Axelrod starts on his home turf, with the prisoner's dilemma game, where each player does better by choosing to defect, no matter what the co-player is doing, with the result that mutual defection (rather than the more rewarding mutual cooperation) gets established. The author's celebrated computer tournaments for the many-rounds game, where cooperation won, were based on a narrow sample of some dozen strategies submitted by eminent experts. But Axelrod later adapted the genetic algorithms of his colleague John Holland to create and test a large set of new, randomly generated strategies.

This ground-breaking work from the mid-1980s, which is reprinted as the first chapter in the book, remains one of the most elegant and convincing examples of genetic programming. Somewhat disappointingly, Axelrod does not elaborate in his introduction on the remarkable subsequent development in the field of reciprocal aid. Interested readers will have to refer to other publications instead — Axelrod's own periodical reviews, for instance, are considerably better documented.

The same criticism applies to the chapter on promoting norms (including 'metanorms' demanding to punish those who disobey norms): Axelrod does no justice to a wealth of later developments (by Boyd, Sugden and Young, to name but a few) which were stimulated to a large extent by his own work. Instead, the reader is offered detailed information on the various political committees on security, arms control and so on, using Axelrod's expertise: a mild form of the syndrome plaguing many political scientists since Henry Kissinger's heyday.

It is on this question of practical impact that he becomes less convincing. By reading Axelrod, politicians can obtain (like everyone else) a better understanding of the game they are playing, but they will not become better at playing it. Axelrod's abstractions should be used as thought experiments only, not as flight trainers.

Consider, for instance, Axelrod's spin-glass model for choosing sides in a political conflict. It is essentially a physicist's world-view: the nation states have a certain propensity to align with each other on the basis, say, of ethnic, religious, territorial, governmental and historical issues. The nations can change side one at a time, thereby reducing their frustration. One can compute which alignments cause minimal frustration in the whole system.

Axelrod does this for the Europe of 1936, and finds two stable configurations. One consists essentially of the Soviet Union against the rest of Europe, the other of the Axis powers against all comers. A couple of countries misbehave but, for a 'prediction' of the actual alliance, this is pretty good. As Niels Bohr used to say, however, it's "predicting in advance" where things become hard. Besides, Winston Churchill offered an even simpler explanation of Europe's politics which carries greater conviction: in his view, the Second World War was just the continuation of the First World War, with a 20-year truce in between.

This is not to deny that Axelrod's spin-glass diplomacy is ingenious, and helps in approaching 'what if' questions (for example, what if some territorial dispute had been settled, or some country not remained neutral). In fact, it should serve as a gold mine for political scientists.

The same holds for Axelrod's tribute model, which displays the emergence of major powers and their dissolution by imperial overstretch, as well as for his lattice model on the dissemination of cultural traits, which exhibits a fascinating and thoroughly eye-opening interplay between local convergence and global polarization. In each case, Axelrod manages to find a minimalistic model with a maximum of interesting features. He can afford blissfully to neglect previous work (for instance, on the game theory of coalition formation, or on rational behaviour) because his original approach is often more to the point. Each of his models is a first step in a promising direction.

The knack for simplicity seems almost an instinct with him; this instinct also tells him to stop before complexity really sets in. □

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Bar fun

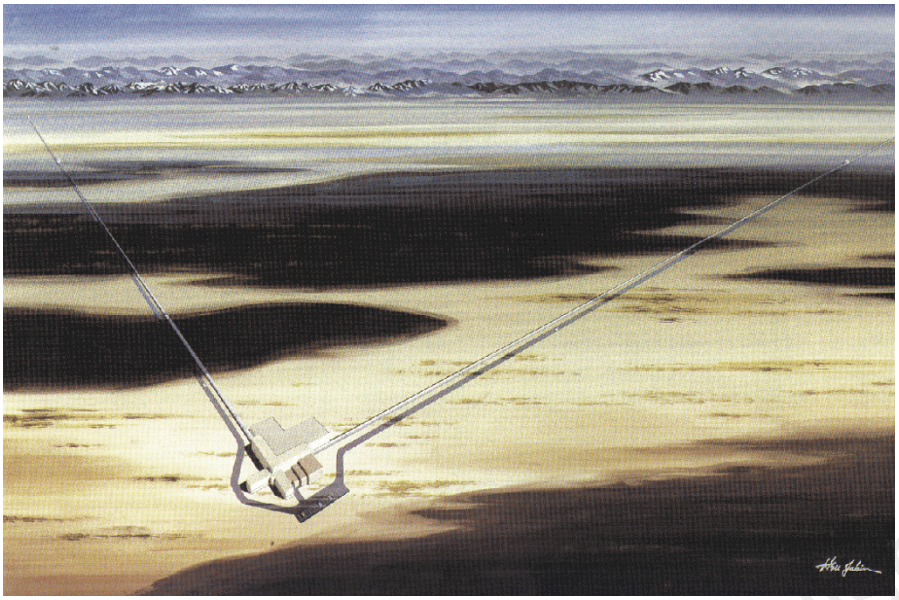
Ripples on a Cosmic Sea: The Search for Gravitational Waves
by David Blair and George McNamara
Allen and Unwin/Addison-Wesley: 1998. Pp. 179. Aus$17.95, £7.99, $22 (pbk)

Harry Collins

Spin a nuclear submarine about its short axis until it is near to breaking and the general theory of relativity says it will emit gravitational radiation of about 10^{-24} watts. This is not much; an ant walking up a wall uses 10^{-7} watts.

The comparison is found in *Ripples on a Cosmic Sea*, and shows why, to outsiders, the search for gravitational waves seems almost crazy. Nevertheless, the US National Science Foundation has funded a joint project between the California Institute of Technology and the Massachusetts Institute of Technology that uses two huge interferometers to look for such shivers in space-time. The interferometers are like Michelson–Morley experiments but with arms 4 kilometres long. Similar but smaller devices are being built in Europe and Japan, and David Blair's group is part of an Australian collaboration that has made a start on another, near Perth.

The interferometers are only the latest stage in a story that started in the 1960s when Joseph Weber of the University of Maryland put together the first resonant detector. He hung bars of aluminium weighing a couple of tons inside vacuum chambers, insulating them from all known influences. When two



Ripple detector: artist's impression of the Laser Interferometer Gravitational-Wave Observatory, taken from the LIGO website (http://www.ligo.caltech.edu).

bars separated by thousands of miles 'rang' in coincidence, Weber argued that gravitational waves were a putative cause of the disturbance; the source could be cosmic catastrophes such as supernovae.

By the early 1970s, Weber's claims had become so forceful that others built similar devices, but by the mid-1970s most people thought Weber was mistaken. Blair and George McNamara provide a colourful description of a confrontation between Weber and Richard Garwin at a conference in the 1970s that might have come to blows had the chairman not stepped in. Weber continues to press his claims, but most of the rest of the field moved on long ago.

The next generation of detectors were Weber bars cooled to liquid-helium temperatures and below. Blair himself runs such a device, although his bar is niobium rather than aluminium. Such attempts to detect gravitational waves are dealt with in the last third of the book. The first section is a short history of science, taking us through Newton to general relativity and the curvature of space, and in the middle is a section about potential sources of gravitational waves. The 'nuclear submarine problem' makes it impossible to generate detectable fluxes on Earth, so we must look to cosmic sources. The huge curvatures and energies associated with cavorting neutron stars and black holes make them the current favourites.

Astronomers Joseph Taylor and Russell Hulse studied the decay of a pair of orbiting pulsars over 20 years. The slowdown of 70 microseconds per year in an orbit of seven-and-three-quarter hours fits well with the predicted loss of energy through gravitational radiation. The 1993 Nobel prize for physics was awarded to Taylor and Hulse for this first indirect confirmation of the existence of the waves, but direct observation is still the holy grail.

Towards the end of their orbital decay (in about 300 million years for the Taylor–Hulse pair), neutron stars nearly touch and circle hundreds of times per second. The final inspiral should produce a characteristic 'chirrup' of gravitational radiation of enormous power, about as bright as 100,000 galaxies. But even these immense fluxes will bend space so little that they will be on the edge of detectability by the most advanced interferometers now being designed. Colliding black holes should be even more fun, and there ought also to be a just-detectable background of gravitational radiation left over from the Big Bang.

Ripples on a Cosmic Sea is currently without competitors. However, parts of the book are so relentlessly 'popular' as to be patronizing. The most informative chapters are those dealing with pulsar sources, and those describing detectors and their inventors. Chapter 12, on laser interferometry, is especially good. It presents important ideas clearly, not shirking complicated new techniques. It also mentions the more operatic organizational upheavals that have attended the US programme and the dirty dealings associated with the funding of different national projects. These chapters provide a nice account of sources and technology and a good thumbnail sketch of the field's history. The book could then be passed on to a young niece or nephew.

Those who get a taste for the science of gravitational radiation detection from the book might want to borrow a library copy of Peter Saulson's *Principles of Interferometric Gravitational Radiation Detectors*, which includes a short section on resonant bars, or Blair's edited collection of technical essays *The Detection of Gravitational Waves*. In both books the equations are supplemented with good clear writing, but you'll need to be rich to buy them. □

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Disregarding the social sciences

Is the Temperature Rising? The Uncertain Science of Global Warming
by S. George Philander
Princeton University Press: 1998. Pp. 258. $35, £22.50

Hans von Storch

'Global warming' has become a household term; it needs no explanation when used in the news. 'Is the temperature rising?' is a question of utmost interest to anyone concerned about the global environment. Both phrases announce the subject of this book.

The volume is based on a course for undergraduate students given by the author at Princeton University, so it is also well suited to educated laypeople. It is written clearly and contains informative figures. The extensive appendices provide additional technical material, and an eight-page glossary is included.

The author explains complex scientific concepts in a precise language and with delightful illustrations. Of the waves on the ocean's surface, he writes: "A breeze that blows over the ocean, like a bow that strokes a violin string, readily excites music in the form of waves. The audible sound of a violin is soothing when the pressure from the bow is gentle and becomes strident when the pressure is great. The ocean's music changes similarly from ripples … to foaming, lashing waves as the gentle breeze grows stiff … and becomes a gale that whips the ocean into frenzy." He describes the weather as the "music of our sphere" and explains the principle of chaos using a thought-experiment of a skier losing his or her wallet on a slope. The book is a pleasure to read.

But its title is deceptive. Most of the volume explains the workings of the climate machinery and its components such as radiation, clouds, weather and oceans. The question 'Is the temperature rising?' is dealt with only on two pages in the last chapter.

The answer is 'yes', which will be no surprise to anybody who knows the observational record compiled by the University of East Anglia in England. The more interesting question 'Will the temperature continue to rise?' is dealt with in even fewer lines: the author quotes "very probable" rates of increase of 0.5–2 °C until about 2050, from