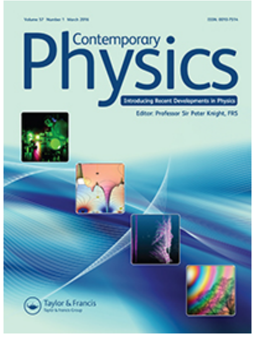

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Natural complexity: a modelling handbook by P. Charbonneau

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BOOK REVIEW

Natural complexity: a modelling handbook, by P. Charbonneau, Princeton, Princeton University Press, 2017, 376 pp., £41.95 (paperback), ISBN 9781400885497. Scope: handbook, textbook. Level: general readership, undergraduate, postgraduate, early career researcher, teacher, scientist.

Some key concepts of complexity science constitute a way of understanding the dynamics and the evolution of many distinct physical and biological phenomena. Even though there is no current definition of what complexity science is, there is a common agreement that it provides ideas and principles, many of which have emerged from or been influenced by other disciplines. The present book is an attempt to introduce some basic notions of complex systems. It is not a surprise at all that the author declares in several places that he does not dare to give a definition of the field. Rather, he has taken an approach by which different models are defined and described throughout the book, attempting to engage readers in the learning process by developing an understanding of a rich collection of examples related to natural phenomena such as epidemic diseases, various sorts of avalanches, patterns build by chemical reactions, earthquakes, collective motions of animals. This is what justifies 'Natural Complexity' in the title of the book.

As a matter of fact, this textbook has been inspired by the class notes of an undergraduate course 'Introduction to computational physics' given by the author, a solar physicist, at the Physics Department of the University of Montreal. Needless to say, there are numerous mathematical and computational techniques that can be used for modelling complex systems. Among them, we can use diverse tools from dynamical systems theory, such as differential equations, either ordinary or partial or discrete dynamical systems. In this case, the main idea is the extensive use of cellular automata. In fact, one of the initial chapters is devoted precisely to the general problem of iterated growth in one and two dimensions, where the basic ideas of cellular automata are clearly described. This is instrumental for the remainder of the chapters. Most computational implementations of the examples of complex systems carried out all throughout the book are actually defined over lattices, where the interconnected nodes represent dynamical variables, and a set of rules define the evolution of the system. I think this is the underlying idea behind the choice of examples contained in the book.

The contents are distributed in 12 chapters and 4 appendices, with the intention of clarifying some computational and mathematical aspects. Each chapter is mainly devoted to one complex system model, including models of aggregation, percolation, sandpiles, forest fires, traffic jams, earthquakes, epidemics, flocking and pattern formation. Ideas from fractal geometry such as self-similarity and scale invariance are used for the description of some aggregation models such as diffusion-limited aggregation, and other natural phenomena. Basic concepts derived from statistical physics and network science, such as criticality or self-organised criticality, and scale-free and small-world networks are also used. Networks play a relevant role mainly in the description of epidemics. The book ends with an epilogue with some delightful personal experiences of patterns found by the author in Nature, historical insights by Kepler, and the use of certain tools from complexity science for the study and prediction of solar flares.

I have found of special interest the idea of including computer codes for the examples in the book, from which most of the figures have been obtained. The quality of the figures is also remarkable, providing much insight about the models. The computer code is written in Python, and certainly can be very helpful for readers to run the simulations by themselves. Furthermore, each chapter ends with a section containing six exercises and computational explorations, where one of them constitutes, as termed by the author, a *Grand Challenge*, which could be used as a student project. At the end of every chapter, there appears an exhaustive and useful list of references, with interesting comments. All this material justifies the subtitle 'A Modelling Handbook' since it can be very conveniently used for exploring and learning about complexity through the examples.

There is a certain enthusiasm distilled by the author all through the book, transporting the reader on a journey of discovery of a chosen set of complex systems, from where diverse insights into complexity science can be grasped. Computer scientists interested in agent-based phenomena can find this book engaging. Many of the described models could be used as teaching tools for computational and statistical physics courses. 'Natural Complexity' constitutes an excellent introduction to some perspectives about complexity science that might be appealing to a broad range of readers, from undergraduate college students to professional scientists, and certainly it could be used for teaching purposes as well.

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