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# Complex Systems and Binary Networks

Guanajuato Lectures  
Held at Guanajuato, México  
16–22 January 1995



Springer

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# Preface

A leading figure in Complex Systems once said: “Complex Systems are like beauty: You know it when you see it”. This sentence gives rise, of course, to ample epistemological considerations. The most cheerful which comes to our mind is a remark due to Benoit Mandelbrot: At an early stage of the development of a subject, a certain vagueness in the definition is advantageous in that it doesn't limit future paths of evolution.

But we prefer to focus on the first sentence. Inspired by that sweeping definition, we have taken a direct, hands-on approach to this subject, which is wide open, multiple and open to joyful innovations. The origin of the list of topics is therefore our unbounded desire to learn and explore, which we hope the reader shares.

The mathematics of complex systems weaves its web over a wide range of fields. From the theory of information to knot theory, from neural computing to evolution theory, from galaxy formation to the birth of universes, most areas of modern physics stand to receive some new insight from complex systems theory.

Conversely, in order to understand complex systems one must draw inspiration from various sources and break free from overspecialization. That is the practical motivation for this work. To promote the cross-fertilization of ideas, we attempted to select a sampling of contributions such that each has something to learn from every other, and something to offer in return.

The book is structured so as to begin with those contributions which help to set up a general theoretical framework, and end with selected applications to particular areas of physics, in particular biophysics (RNA), statistical physics (Ising and Potts models) and astrophysics and cosmology.

In the attempts to measure complexity Chaitin's stands out for its naturalness. It is also deeply bound to Gödel's theorem, on the mathematics side, and to statistical mechanics and information theory on the physics side.

In the next section, Kauffman succeeds in giving a very clear introduction to knot theory, a subject which has a reputation for being intimidating, and in spelling out its applications to statistical mechanics and topological field theory.

To cap the theoretical structures and move into applications, Stadler offers a mathematical framework to accommodate all problems which can be formulated in terms of a “fitness landscape” over hypercubes, from the Travelling Salesman Problem to RNA secondary structures.

Derrida, a world authority on binary networks, gives us a solid introduction to this topic and to the statistical mechanics related to it, with an emphasis on the physical applications of complexity.

Finally, Smolin proposes a view of the Universe which challenges the imagination, from self-organizing models of galaxy formation to the birth of baby universes and the condensation of structure constants.

Of course no single book can possibly contain an exhaustive list of the developments of complex systems theory. Instead, we have attempted to provide a palette of colors, which the reader is invited to blend into a painting more faithful to his/her own interest and imagination.

Mexico City  
August 1995

R. García-Pelayo  
H. Waelbroeck

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