Book review. Theory of condensed matter

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Book review on *Physics of Complex Systems: Discovery in the Age of Gödel* by Dragutin T. Mihailović, Darko Kapor, Siniša Crvenković and Anja Mihailović (Boca Raton; London; New York: CRC Press; Taylor & Francis Group Publ., 2023)

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This book is the result of the joint efforts of four Serbian scientists — recognized experts in theoretical physics, meteorology, and applied and pure mathematics. During the years of research, they were deeply involved in the study of complex systems in diverse contexts. The inspiration for the book was found in the problems that the authors encountered in teaching and research.

The main subject of the book is the physics of complex systems, which earned the status of a scientific field in its own right about thirty years ago. Since then, it has become a unifying approach to the study of phenomena in complex systems encountered in the frontier fields of physics, chemistry, technology, biology, ecology, and social sciences. Complex systems consist of many interacting components, e. g. building blocks including atoms, molecules, neurons, animals, or persons, which can exhibit emergent behavior that is not dictated exclusively by the classical laws of nature (physics, chemistry, biology). In complexity science, the focus is on understanding the emergent behavior of the system as a whole. A single neuron is not enough to explain consciousness, and the behavior of a single ant does not say much about the incredibly sophisticated organization of ant colonies. What makes consciousness and societies emerge are the interactions between the components, which are more than a collection of independent objects. The nature of these interactions can be physical, e. g. the interaction potential in a system of particles, or be defined by a set of rules that the components follow.

In this book, the authors insist that the understanding of phenomena in the real world surrounding us, consisting of complex systems characterized by nonlinear interactions, requires reasoning opposite to the usual approach stemming from reductionism. Based on the authors' research on these topics, this book puts forward the idea that the applications of information measures can provide new results in the study of complex systems. The authors particularly elaborate on this idea in the first five chapters out of ten, where they consider the philosophical and epistemological issues on which this idea relies. Thus, starting with the discussion on the generality of physics from the perspective to which extent it may

explain phenomena in complex systems, through the discussion of the philosophical and physical understanding of time, building of theories and models, authors gradually lead the reader toward the concept of information and information measures, and their applications in complex systems.

The usefulness of such an approach in the studies of real-world phenomena is illustrated in the last five chapters, where a collection of the authors' original contributions to the physics of complex systems in diverse scientific areas has been presented. Examples include the application of Kolmogorov and Aksentijevic–Gibson complexity in a search for patterns in the analysis of Bell's experiments, the identification of gravitational waves (LIGO experiment), and environmental fluid flows; separation of scales in complex systems as a reflection of Gödel's incompleteness theorems; and discussion of randomness in turbulent flows and its quantification via complexity by considering information measures suitable for its description. A particularly interesting example is the discussion of the role of the physics of complex systems in explaining an impression about a picture through the perception analyzed with change complexity and the recognition of order and disorder with entropy. Finally, the applications of the physics of complex systems to medical sciences are illustrated through models and approaches dealing with intercellular communication, autoimmune diseases, and brain disorders.

This is one of the most original texts on complex systems. The authors were inspired to write it by the work of Kurt Gödel, 'whose daring approach through reasoning opposite to accumulated experience and mainstream inspired many researchers to make breakthroughs.' As the authors emphasize, this book is not a textbook. It may not help by directing how to deal with specific problems. Nevertheless, it may be a reason why to study them.

About the authors

Dragutin T. Mihailović is a retired Professor in Meteorology, Environmental Fluid Mechanics, and Biophysics at the University of Novi Sad, Serbia. He has achieved outstanding results in subjects related to land–atmosphere processes, air pollution, chemical transport modeling, boundary layer meteorology, physics and modeling of phenomena on environmental interfaces, modeling of complex systems, nonlinear dynamics, and complexity.

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Conflict of Interest

The author declares that there is no conflict of interest, either existing or potential.