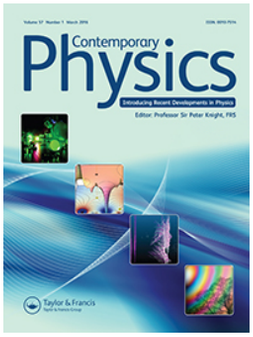

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An introduction to space plasma complexity, by Tom Tien Sun Chang

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BOOK REVIEW

An introduction to space plasma complexity, by Tom Tien Sun Chang, Cambridge, Cambridge University Press, 2015, 192 pp., £65 (hardback), ISBN 978-0-5216-4262-0. Scope: monograph. Level: postgraduate, early career researcher, researcher, specialist.

One of the flourishing and fascinating research areas in physics nowadays is the physics of complex systems, or the theory of complexity. There is not a single and straightforward meaning associated with this buzzword due to its vagueness and polysemy, and very often it depends on the context and the authors. Nevertheless, one of the interesting points is the tools and methods that the theory provides that can be eventually applied to many different disciplines, ranging from physics, chemistry, biology, applied sciences, and even social sciences.

The main idea of complexity that the author uses in the present monograph stems from the non-linear interaction of the individual parts of a dynamical system and the different sizes of large-scale coherent structures that emerge. The book abounds in numerous examples of complex phenomena related to observed plasma processes in the heliosphere, the Earth's magnetosphere and the ionosphere. Here, we have an extraordinary book where interesting problems associated with the space and astrophysical plasmas are considered under the viewpoint of several key concepts that fall under the umbrella of the complexity, such as self-organised criticality, dynamic renormalization group, and multifractal measures.

The author, Tom Chang, is one of the top space plasma physicists on complexity, self-organised criticality and intermittent turbulence. He has directed the activities of theoretical plasma physics at MIT for more than 30 years.

Among the goals of this introductory text are not contemplating every aspect of the methodologies used in complexity theory to the physics of space plasma. It presents a personal, careful and authoritative selection of the most important aspects. The selected concepts from the theory of complexity are used in numerous applications and current developments in the field. Clearly one of his objectives is to advocate for the fascinating and developing field, space plasma complexity, with the hope of providing an opportunity for new students and researchers in this field, in which he has been working for many years of his life.

Most of the problems to which the author refers to constitute very recent research problems in the field of space plasma, and the book contains at the end a very rich list of important references in the field, that the author uses along the whole book.

The book is very well edited and it contains seven chapters, where key aspects of complexity theory applied to space plasmas are discussed. It starts with an excellent introduction where the objectives of the book are clearly outlined, and basically the rest of the chapters are devoted to either give the terminology that it will be used in the next chapters, or to describe methods and different applications. A second chapter deals extensively with the idea of dynamical criticality far from equilibrium. The theory of self-organised criticality is introduced and applied to different examples. Interestingly, this theory helped to recognise the power-law behaviour of the solar flares. Next, under the title of physics of complexity, the author describes coherent structures and explores the physical reasons of the origin of complexity in space plasmas. The next chapters deal with other techniques such as probability distributions, wavelets, fractals, multifractal analysis, ending with a final chapter on the dynamical renormalization group and its connection with criticality and multifractals. The phenomenon of intermittency and fluid turbulence using these techniques is also discussed. Including such topics as the solar wind turbulence, turbulent fluctuations in the magnetospheric cusp and intermittency of broad-band turbulence in the ionosphere. Numerous figures helping to illustrate many abstract ideas and techniques appear throughout the whole text. Furthermore, many of the figures appear in colour plates as well, when needed for a better understanding of them.

A nice finale advocates for the use of the concepts and methodologies espoused in the monograph in the research activities of the prospective readers inviting them all to the study and exploration of this field full of novelty.

The monograph will be primarily of special interest to students and researchers in the field of space plasma to learn how ideas coming from the theory of complexity can be applied and explain some complex phenomena occurring in the space plasma environment. Nevertheless, I believe it can be also useful for theoretical physicists and applied mathematicians interested in the applications of ideas of non-linear dynamics, statistical physics and complex systems to a field which is not sufficiently well known.

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