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Book Review

New Methods for Chaotic Dynamics. By Nikolai A. Magnitskii and Sergey V. Sidorov. Singapore: World Scientific, 2006. 363 pp. + xvii. ISBN 981-256-817-4.

Work on what exactly happens in chaotic dynamics has evolved, and work on higher-dimensional systems has become intricate and subtle. As psychological processes are very often meaningfully concept-tualized only in higher dimensions than two, and the focus of this book is on dissipative systems with three or more dimensions, it has wide implications. This erudite work is not for beginners, and it questions many simple rules for identifying the presence of chaos, such as those based on the signs of Lyapunov exponents. The authors make it clear that they consider their work, that is presented from the perspective of ordinary differential equations, has application in the physical, biolog-ical and social sciences, though most of the examples are very detailed re-examination of the evolution of such systems as the Lorenz attractor.

The earlier chapters cover basic definitions, singular points, manifolds, periodic and nonperiodic solutions, limit cycles, tori, dimensions and fractals, bifurcations and structural stability are considered and illustrated. Chapter two leads into a very detailed analysis of what local and nonlocal bifurcations actually involve. Saddle nodes and saddle foci are introduced and illustrated, and approximate methods of analysis reviewed. Only then can the authors begin to distinguish different cascades of bifurcations and paths to chaos. Cascades such as the fairly familiar Ruelle-Takens scenario are covered, but also that of Pomeau-Manneville that involves intermittency.

Chapter three presents what must be the most intricate analysis of the Lorenz Equations ever considered, and it is then used as a methodological paradigm for studying some other attractors that are all variants of the three variable Lorenz structure with one cross-product term, but extending to two or three cross-products, as in the Vallis, Rikitaki or Rabinovoch-Fabrikant systems. I admit to a personal fascination with the El-Nino equations created by Vallis for modeling the climate that seriously affects where I live in South-Eastern Australia.

The central thesis of this book is summarized in italics on page 190, and is as follows. “Any scenario of transition to chaos always begins with the Feigenbaum period doubling cascade of bifurcations of some original stable cycle. Then it always continues with the Sharkovskii complete or incomplete subharmonic cascade of bifurcations of stable cycles of arbitrary period up to the cycle of period three. Then the further continuation of any scenario is always the Magnitskii complete or incomplete homoclinic cascade of bifurcations of stable cycles converging to homoclinic contours of singular points or singular cycles.”

The authors do not rest on this formidable intellectual achievement, however, as they consider infinite-dimensional systems in Chapter five, such as the Brusselator, and spatio-temporal chaos in the Kuramoto-Tsuzuki equation. Delay as a cause of nonlinearity, and chaos control by various methods that are not yet well known, complete the review.

The book includes the first treatment I have seen of the problem of the existence of inverse functions for chaotic systems, which has application in security encoding and the retrieval of noisy signals, and in sensory psychophysics. The bibliography includes some familiar papers but also a number that have not been translated from their Russian originals, and so get some first valuable English-language exposure in this book. The copyediting standards in places are deplorable; the scholarly and diligent authors are not well served when the text is left in places as a mixture of English vocabulary and Russian syntax. If the reader is familiar with both languages and mathematics he or she can disentangle what is being communicated, otherwise one must sadly give that bit a miss.

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