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Vadim S. Anishchenko  
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Galina I. Strelkova

# Deterministic Nonlinear Systems

A Short Course

 Springer

# Deterministic Nonlinear Systems A Short Course Springer Series In Synergetics

**Hermann Haken**



## **Deterministic Nonlinear Systems A Short Course Springer Series In Synergetics:**

Deterministic Nonlinear Systems Vadim S. Anishchenko, Tatyana E. Vadivasova, Galina I. Strelkova, 2014-06-16 This text is a short yet complete course on nonlinear dynamics of deterministic systems. Conceived as a modular set of 15 concise lectures, it reflects the many years of teaching experience by the authors. The lectures treat in turn the fundamental aspects of the theory of dynamical systems, aspects of stability and bifurcations, the theory of deterministic chaos and attractor dimensions, as well as the elements of the theory of Poincaré recurrences. Particular attention is paid to the analysis of the generation of periodic, quasiperiodic, and chaotic self-sustained oscillations and to the issue of synchronization in such systems. This book is aimed at graduate students and non-specialist researchers with a background in physics, applied mathematics, and engineering wishing to enter this exciting field of research.

### **Introduction to Nonlinear Oscillations**

Vladimir I. Nekorkin, 2016-05-02 A systematic outline of the basic theory of oscillations combining several tools in a single textbook. The author explains fundamental ideas and methods while equally aiming to teach students the techniques of solving specific practical or more complex problems. Following an introduction to fundamental notions and concepts of modern nonlinear dynamics, the text goes on to set out the basics of stability theory as well as bifurcation theory in one and two dimensional cases. Foundations of asymptotic methods and the theory of relaxation oscillations are presented with much attention paid to a method of mappings and its applications. With each chapter including exercises and solutions, including computer problems, this book can be used in courses on oscillation theory for physics and engineering students. It also serves as a good reference for students and scientists in computational neuroscience.

*Neutrices and External Numbers* Bruno Dinis, Imme van den Berg, 2019-07-03 *Neutrices and External Numbers* A Flexible Number System introduces a new model of orders of magnitude and of error analysis with particular emphasis on behaviour under algebraic operations. The model is formulated in terms of scalar neutrices and external numbers in the form of an extension of the nonstandard set of real numbers. Many illustrative examples are given. The book starts with detailed presentation of the algebraic structure of external numbers, then deals with the generalized Dedekind completeness property, applications in analysis, domains of validity of approximations of solutions of differential equations, particularly singular perturbations. Finally, it describes the family of algebraic laws characterizing the practice of calculations with external numbers. Features: Presents scalar neutrices and external numbers, a mathematical model of order of magnitude within the real number system. Outlines complete algebraic rules for the neutrices and external numbers. Conducts operational analysis of convergence and integration of functions known up to orders of magnitude. Formalises a calculus of error propagation covariant with algebraic operations. Presents mathematical models of phenomena incorporating their necessary imprecisions, in particular related to the Sorites paradox.

### **Subject Guide to Books in Print ,1991**

*Comprehensive Human Physiology* Rainer Greger, Uwe Windhorst, 2013-11-11 *Comprehensive Human Physiology* is a significantly important publication on physiology presenting

state of the art knowledge about both the molecular mechanisms and the integrative regulation of body functions This is the first time that such a broad range of perspectives on physiology have been combined to provide a unified overview of the field This groundbreaking two volume set reveals human physiology to be a highly dynamic science rooted in the ever continuing process of learning more about life Each chapter contains a wealth of original data clear illustrations and extensive references making this a valuable and easy to use reference This is the quintessential reference work in the fields of physiology and pathophysiology essential reading for researchers lecturers and advanced students *Mathematical Reviews*,1980 *The Construction of Cognitive Maps* Juval Portugali,2007-08-23 and processes which are exclusive to humans in their encoding storing decoding and retrieving spatial knowledge for various tasks The authors present and discuss connectionist models of cognitive maps which are based on local representation versus models which are based on distributed representation as well as connectionist models concerning language and spatial relations As is well known Gibson s 1979 ecological approach suggests a view on cognition which is diametrically different from the classical main stream view perception and thus cognition is direct immediate and needs no internal information processing and is thus essentially an external process of interaction between an organism and its external environment The chapter by Harry Heft introduces J J Gibson s ecological approach and its implication to the construction of cognitive maps in general and to the issue of wayfinding in particular According to Heft main stream cognitive sciences are essentially Cartesian in nature and have not as yet internalized the implications of Darwin s theory of evolution Gibson in his ecological approach has tried to do exactly this The author introduces the basic terminology of the ecological approach and relates its various notions in particular optic flow nested hierarchy and affordances to navigation and the way routes and places in the environment are learned *The Cosmo-Creative Society* Ake E. Andersson,David F. Batten,Kiyoshi Kobayashi,Kazuhiro Yoshikawa,2012-12-06 Today telecommunication systems are expanding and evolving at a remarkable rate with the aid of fiber optics satellites and computerized switchboard systems Airline systems are providing faster and more efficient networks for world wide human transportation Computers are now generally accessible to virtually all industries and many households But perhaps the most important factor is that education systems are expanding the knowledge base for city populations thus resulting in increased efficiency in the use of computers telecommunications and rapid transportation systems The revolutionary age of logistical networks is upon us Logistical networks are those systems which facilitate the movement of knowledge commodities money and people in association with the production or consumption of goods and services Logistical networks form a set of important infrastructure which serve as hard and soft means to sustain all kinds of movement transactions and diffusion within and between global networks of cities Major structural changes in the regional and urban economy culture and institutions are triggered by slow but steady changes in global logistical systems *Nonlinear Dynamics of Chaotic and Stochastic Systems* Vadim S. Anishchenko,Vladimir Astakhov,Alexander Neiman,Tatjana Vadivasova,Lutz

Schimansky-Geier, 2007-07-20 We present an improved and enlarged version of our book *Nonlinear Dynamics of Chaotic and Stochastic Systems* published by Springer in 2002. Basically the new edition of the book corresponds to its first version. While preparing this edition we made some clarifications in several sections and also corrected the misprints noticed in some formulas. Besides three new sections have been added to Chapter 2. They are: Statistical Properties of Dynamical Chaos, Effects of Synchronization in Extended Self-Sustained Oscillatory Systems, and Synchronization in Living Systems. The sections indicated reflect the most interesting results obtained by the authors after publication of the first edition. We hope that the new edition of the book will be of great interest for a wide section of readers who are already specialists or those who are beginning research in the fields of nonlinear oscillation and wave theory, dynamical chaos, synchronization, and stochastic process theory.

Saratov, Berlin, and St. Louis, V. S. Anishchenko, November 2006, A. B. Neiman, T. E. Vadiavasova, V. V. Astakhov, L. Schimansky-Geier.

**Preface to the First Edition** This book is devoted to the classical background and to contemporary results on nonlinear dynamics of deterministic and stochastic systems. Considerable attention is given to the effects of noise on various regimes of dynamics systems with noise-induced order. On the one hand, there exists a rich literature of excellent books on nonlinear dynamics and chaos; on the other hand, there are many marvelous monographs and textbooks on the statistical physics of far from equilibrium and stochastic processes. This book is an attempt to combine the approach of nonlinear dynamics based on the deterministic evolution equations with the approach of statistical physics based on stochastic or kinetic equations. One of our main aims is to show the important role of noise in the organization and properties of dynamic regimes of nonlinear dissipative systems.

**Complex Nonlinearity** Vladimir G. Ivancevic, Tijana T. Ivancevic, 2008-05-31 *Complex Nonlinearity: Chaos, Phase Transitions, Topology Change, and Path Integrals* is a book about prediction and control of general nonlinear and chaotic dynamics of high-dimensional complex systems of various physical and non-physical nature and their underpinning geometro-topological change. The book starts with a textbook-like expose on nonlinear dynamics, attractors, and chaos, both temporal and spatio-temporal, including modern techniques of chaos control. Chapter 2 turns to the edge of chaos in the form of phase transitions, equilibrium and non-equilibrium oscillatory, fractal, and noise-induced, as well as the related field of synergetics. While the natural stage for linear dynamics comprises of flat Euclidean geometry with the corresponding calculation tools from linear algebra and analysis, the natural stage for nonlinear dynamics is curved Riemannian geometry with the corresponding tools from nonlinear tensor algebra and analysis. The extreme nonlinearity chaos corresponds to the topology change of this curved geometrical stage, usually called configuration manifold. Chapter 3 elaborates on geometry and topology change in relation with complex nonlinearity and chaos. Chapter 4 develops general nonlinear dynamics, continuous and discrete, deterministic and stochastic, in the unique form of path integrals and their action-amplitude formalism. This most natural framework for representing both phase transitions and topology change starts with Feynman's sum over histories to be quickly generalized into the sum over geometries and topologies. The last Chapter puts all the previously developed

techniques together and presents the unified form of complex nonlinearity Here we have chaos phase transitions geometrical dynamics and topology change all working together in the form of path integrals The objective of this book is to provide a serious reader with a serious scientific tool that will enable them to actually perform a competitive research in modern complex nonlinearity It includes a comprehensive bibliography on the subject and a detailed index Target readership includes all researchers and students of complex nonlinear systems in physics mathematics engineering chemistry biology psychology sociology economics medicine etc working both in industry clinics and academia

Dynamics of Nonlinear Time-Delay Systems Muthusamy Lakshmanan, Dharmapuri Vijayan Senthilkumar, 2013-02-27 Synchronization of chaotic systems a patently nonlinear phenomenon has emerged as a highly active interdisciplinary research topic at the interface of physics biology applied mathematics and engineering sciences In this connection time delay systems described by delay differential equations have developed as particularly suitable tools for modeling specific dynamical systems Indeed time delay is ubiquitous in many physical systems for example due to finite switching speeds of amplifiers in electronic circuits finite lengths of vehicles in traffic flows finite signal propagation times in biological networks and circuits and quite generally whenever memory effects are relevant This monograph presents the basics of chaotic time delay systems and their synchronization with an emphasis on the effects of time delay feedback which give rise to new collective dynamics Special attention is devoted to scalar chaotic hyperchaotic time delay systems and some higher order models occurring in different branches of science and technology as well as to the synchronization of their coupled versions Last but not least the presentation as a whole strives for a balance between the necessary mathematical description of the basics and the detailed presentation of real world applications

*Nonlinear Systems* Shankar Sastry, 2014-01-15 Nonlinear Dynamics of Deterministic and Stochastic Systems Igor Khovanov, 2013

**Nonlinear Dynamics** Muthusamy Lakshmanan, Shanmuganathan Rajaseekar, 2012-12-06 Integrability chaos and patterns are three of the most important concepts in nonlinear dynamics These are covered in this book from fundamentals to recent developments The book presents a self contained treatment of the subject to suit the needs of students teachers and researchers in physics mathematics engineering and applied sciences who wish to gain a broad knowledge of nonlinear dynamics It describes fundamental concepts theoretical procedures experimental and numerical techniques and technological applications of nonlinear dynamics Numerous examples and problems are included to facilitate the understanding of the concepts and procedures described In addition to 16 chapters of main material the book contains 10 appendices which present in depth mathematical formulations involved in the analysis of various nonlinear systems

*Synergetics* Hermann Haken, 2004-01-12 This book is an often requested reprint of two classic texts by H Haken *Synergetics* An Introduction and *Advanced Synergetics* *Synergetics* an interdisciplinary research program initiated by H Haken in 1969 deals with the systematic and methodological approach to the rapidly growing field of complexity Going well beyond qualitative analogies between complex

systems in fields as diverse as physics chemistry biology sociology and economics Synergetics uses tools from theoretical physics and mathematics to construct an unifying framework within which quantitative descriptions of complex self organizing systems can be made This may well explain the timelessness of H Haken s original texts on this topic which are now recognized as landmarks in the field of complex systems They provide both the beginning graduate student and the seasoned researcher with solid knowledge of the basic concepts and mathematical tools Moreover they admirably convey the spirit of the pioneering work by the founder of Synergetics through the essential applications contained herein that have lost nothing of their paradigmatic character since they were conceived

Nonlinear Systems Nathan van de Wouw,Erjen Lefeber,Ines Lopez Arteaga,2016-07-07 This treatment of modern topics related to the control of nonlinear systems is a collection of contributions celebrating the work of Professor Henk Nijmeijer and honoring his 60th birthday It addresses several topics that have been the core of Professor Nijmeijer s work namely the control of nonlinear systems geometric control theory synchronization coordinated control convergent systems and the control of underactuated systems The book presents recent advances in these areas contributed by leading international researchers in systems and control In addition to the theoretical questions treated in the text particular attention is paid to a number of applications including mobile robotics marine vehicles neural dynamics and mechanical systems generally This volume provides a broad picture of the analysis and control of nonlinear systems for scientists and engineers with an interest in the interdisciplinary field of systems and control theory The reader will benefit from the expert participants ideas on important open problems with contributions that represent the state of the art in nonlinear control

**Stabilization and Regulation of Nonlinear Systems** Zhiyong Chen,Jie Huang,2014-08-30 The core of this textbook is a systematic and self contained treatment of the nonlinear stabilization and output regulation problems Its coverage embraces both fundamental concepts and advanced research outcomes and includes many numerical and practical examples Several classes of important uncertain nonlinear systems are discussed The state of the art solution presented uses robust and adaptive control design ideas in an integrated approach which demonstrates connections between global stabilization and global output regulation allowing both to be treated as stabilization problems Stabilization and Regulation of Nonlinear Systems takes advantage of rich new results to give students up to date instruction in the central design problems of nonlinear control problems which are a driving force behind the furtherance of modern control theory and its application The diversity of systems in which stabilization and output regulation become significant concerns in the mathematical formulation of practical control solutions whether in disturbance rejection in flying vehicles or synchronization of Lorenz systems with harmonic systems makes the text relevant to readers from a wide variety of backgrounds Many exercises are provided to facilitate study and solutions are freely available to instructors via a download from [springerextras.com](http://springerextras.com) Striking a balance between rigorous mathematical treatment and engineering practicality Stabilization and Regulation of Nonlinear Systems is an ideal text for graduate students from many engineering and applied

mathematical disciplines seeking a contemporary course in nonlinear control Practitioners and academic theorists will also find this book a useful reference on recent thinking in this field      **Integrability of Nonlinear Systems** Yvette

Kosmann-Schwarzbach, Basil Grammaticos, K.M. Tamizhmani, 2004-02-17 The lectures that comprise this volume constitute a comprehensive survey of the many and various aspects of integrable dynamical systems The present edition is a streamlined revised and updated version of a 1997 set of notes that was published as Lecture Notes in Physics Volume 495 This volume will be complemented by a companion book dedicated to discrete integrable systems Both volumes address primarily graduate students and nonspecialist researchers but will also benefit lecturers looking for suitable material for advanced courses and researchers interested in specific topics      **Advanced Synergetics** Hermann Haken, 2012-12-06 This text on

the interdisciplinary field of synergetics will be of interest to students and scientists in physics chemistry mathematics biology electrical civil and mechanical engineering and other fields It continues the outline of basic concepts and methods presented in my book Synergetics An Introduction which has by now appeared in English Russian Japanese Chinese and German I have written the present book in such a way that most of it can be read independently of my previous book though occasionally some knowledge of that book might be useful But why do these books address such a wide audience Why are instabilities such a common feature and what do devices and self organizing systems have in common Self organizing systems acquire their structures or functions without specific interference from outside The differentiation of cells in biology and the process of evolution are both examples of self organization Devices such as the electronic oscillators used in radio transmitters on the other hand are man made But we often forget that in many cases devices function by means of processes which are also based on self organization In an electronic oscillator the motion of electrons becomes coherent without any coherent driving force from the outside the device is constructed in such a way as to permit specific collective motions of the electrons Quite evidently the dividing line between self organizing systems and man made devices is not at all rigid

Nonlinear Dynamics in Complex Systems Armin Fuchs, 2012-09-22 With many areas of science reaching across their boundaries and becoming more and more interdisciplinary students and researchers in these fields are confronted with techniques and tools not covered by their particular education Especially in the life and neurosciences quantitative models based on nonlinear dynamics and complex systems are becoming as frequently implemented as traditional statistical analysis Unfamiliarity with the terminology and rigorous mathematics may discourage many scientists to adopt these methods for their own work even though such reluctance in most cases is not justified This book bridges this gap by introducing the procedures and methods used for analyzing nonlinear dynamical systems In Part I the concepts of fixed points phase space stability and transitions among others are discussed in great detail and implemented on the basis of example elementary systems Part II is devoted to specific non trivial applications coordination of human limb movement Haken Kelso Bunz model self organization and pattern formation in complex systems Synergetics and models of dynamical properties of neurons



Hodgkin Huxley Fitzhugh Nagumo and Hindmarsh Rose Part III may serve as a refresher and companion of some mathematical basics that have been forgotten or were not covered in basic math courses Finally the appendix contains an explicit derivation and basic numerical methods together with some programming examples as well as solutions to the exercises provided at the end of certain chapters Throughout this book all derivations are as detailed and explicit as possible and everybody with some knowledge of calculus should be able to extract meaningful guidance follow and apply the methods of nonlinear dynamics to their own work This book is a masterful treatment one might even say a gift to the interdisciplinary scientist of the future With the authoritative voice of a genuine practitioner Fuchs is a master teacher of how to handle complex dynamical systems What I find beautiful in this book is its clarity the clear definition of terms every step explained simply and systematically J A Scott Kelso excerpts from the foreword

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