WORLD SCIENTIFIC SERIES ON NONLINEAR SCIENCE
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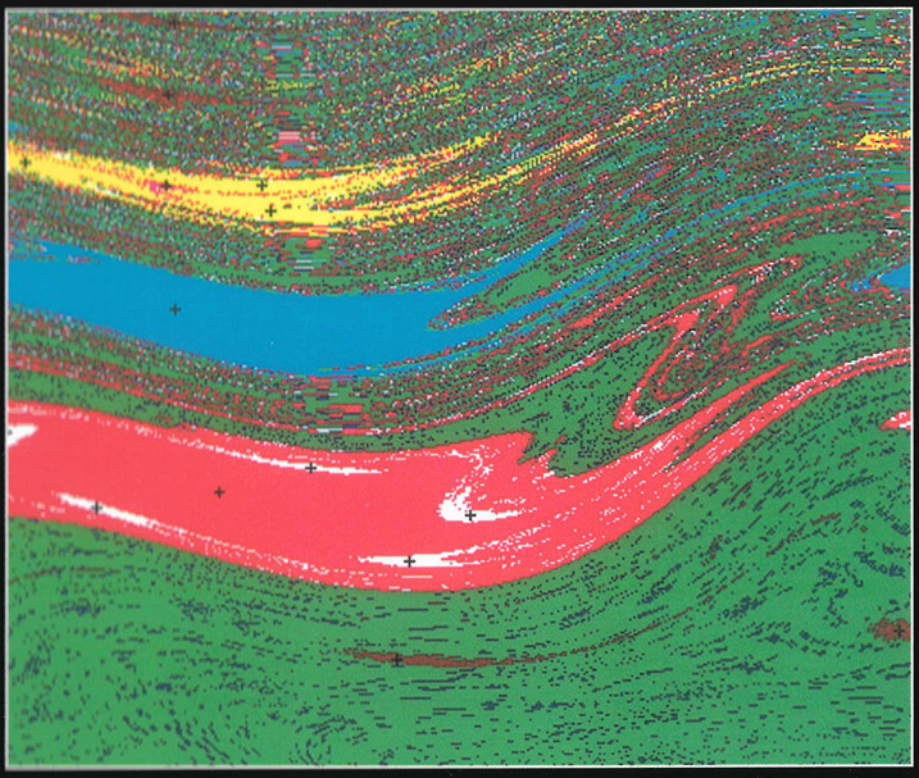
NONLINEAR AND PARAMETRIC PHENOMENA

THEORY AND APPLICATIONS IN RADIOPHYSICAL AND MECHANICAL SYSTEMS

Vladimir Damgov



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World Scientific

NEW JERSEY • LONDON • SINGAPORE • BEIJING • SHANGHAI • HONG KONG • TAIPEI • BANGALORE

Published by

World Scientific Publishing Co. Pte. Ltd.

5 Toh Tuck Link, Singapore 596224

USA office: 27 Warren Street, Suite 401-402, Hackensack, NJ 07601

UK office: 57 Shelton Street, Covent Garden, London WC2H 9HE

British Library Cataloguing-in-Publication Data
A catalogue record for this book is available from the British Library.

NONLINEAR AND PARAMETRIC PHENOMENA
Theory and Applications in Radiophysical and Mechanical Systems

ISBN 981-02-3051-6

Printed in Singapore by World Scientific Printers (S) Pte Ltd

To TANYA,

NADYA, JORDAN, NIKOLAY,

ELIZA and NYA

PREFACE

This monograph concentrates on radiophysical systems; less attention will be focused on purely mechanical systems, but actually the effects, phenomena and regularities are of a general nature and in most of the cases they are valid for mechanical systems as well. By applying the well-known electromechanical analogues, the resultant mathematical expressions and major conclusions can be successfully used in both areas without substantial adjustments.

Radiophysics is an area within the domain of Physics, which, according to the *Great Soviet Encyclopaedia* [1], studies physical processes related to electromagnetic oscillations and waves with frequencies ranging from a few Hz to 10^{11} and over: the object of exploration is their excitation, propagation, interaction, reception and conversion; issues of signal identification against the background of random (fluctuating) processes are also studied. The subject matter of Radiophysics is closely linked with the *General theory of oscillations, SHF electronics, Quantum electronics,* elements of *Physics of plasma, Remote sensing* [2].

The Theory of nonlinear oscillations is *a science* about the most general regularities in dynamic systems. Its separation and differentiation are mostly related to the common analysis of the phenomena and processes, which resulted in major concepts such as oscillating regularity, stability, dynamic systems, etc., losing their primary physical meaning in the course of their development within this theory and ceased to be physical concepts. Parallel to that, besides its high degree of mathematical formalization in the area of applied mathematics, the Theory of nonlinear oscillations has also „materialized" in natural sciences, mostly in Radiophysics, Mechanics and others.

There is a vast bibliography on the General theory of nonlinear oscillations. The majority of the books, however, deal with the principal analytical methods, while any investigation of the various oscillating processes and phenomena, and of their specificity, for example in particular radiophysical and mechanical systems, is conducted for the sole purpose of illustrating either one or another set of approaches. On the other hand, there are a number of interesting treatises dedicated to the examination of particular classes of systems, for example generating, converting or amplifying systems, which, however, have lost sight of the general oscillations approach and of the general comprehension of the occurring processes from an oscillations perspective. The more general view is indispensable for the modern radiophysicists, specialists in mechanics and other physical-and-engineering areas of today, who should use the most adequate methods of analysis and computation in each particular case considering the oscillation processes in various dynamic systems, and who should be well aware of the category of phenomena to which the object of their research or elaboration belongs.

In recent years modern science has surprised us more than once: it has been proved that chaotic regimes are widespread in strictly determined systems without random external action and with a small number of degrees of freedom; an antipodal structural system has also been developed and a new area of research, dealing with the self-organization and synergetic grouping of systems in steady-state formations, has emerged; the Catastrophe theory has been created, etc.

It has been demonstrated that there is a possibility for the appearence of chaotic oscillations in such a classical dynamical system as is an oscillating circuit under the action of a determined external periodic signal. Hence, it is necessary to focus attention on the nonlinear and parametric phenomena that, in recent years, have resulted in a cardinal revision of our ideas of determinism and radomness of the processes, of general and local stability, of computer simulation and possibility for long-term prediction, etc.

The most general considerations stated above have largely determined the nature of this book.

This book deals with modern research issues related to effects and phenomena in four major classes of radiophysical and physico-technical oscillating systems – linear, parametric, nonlinear and nonlinear-parametric. We present some theoretical generalizations and new theoretical formulations in the following areas: modulation-parametric interactions, interpretation of parametric resonance, generator conversion of signals and chaotic instability of systems with delaying self-action, adaptive (synergetic) grouping of radiophysical and physico-technical oscillating systems in stable formations, the new subclass of modulatory nonlinear-parametric systems with adaptive self-tuning, kick-excitable self-adaptive systems. A suitable analytical technique for investigating the set of nonlinear and modulation-parametric phenomena is provided. We establish classification and generalize the regularities in the manifestation of the different nonlinear and parametric effects and phenomena for the purpose of acquiring a general idea. Some methods of realizing radiophysical and physico-technical systems with new functional capacities are described. Radiophysical and physico-technical devices and systems resting on new effects, phenomena and regularities are presented. A generalized analysis of the possible applications is also offered.

Notwithstanding the monographic nature of the book, it can serve: first, as an introduction to some basic paradigms of the Theory of nonlinear oscillations; second, as a source of initial information for post-graduate students and junior researchers on the methods of and approaches to formulating and solving scientific and research problems; third, as a manual on a definite set of effects and phenomena, and on some methods of their analysis to be used by researchers. The book seeks to assist individual research – the art of creation. Hence one will come across examples drawn from both the first and the second line of the scientific front there. The first (heuristic) line – being the identification and investigation of qualitatively new phenomena, development of new methods and theories. The second („conventional" or „extensive") line – being the utilization of the developed

methods for investigating the characteristics and parameters of devices and systems created on the basis of new effects and phenomena found.

A fundamental methodological approach in the structuring of the material is that the presentation of each issue should reflect the overall research cycle – from the general description and classification of effects and phenomena, through the development of an adequate analytical technique, to an analytical, numerical (through computer experiment) and test (natural experiment) investigation of particular devices and systems, and an analysis of the possible applications. The analytical technique is presented in a user-friendly form with the necessary explanations so that the reader can apply it promptly and actively in his creative and research activity.

The book is of an interdisciplinary nature and can serve as a handbook for developing lecture courses such as Fundamentals of Nonlinear Dynamics and Theory of Nonlinear Oscillations, Theory of Nonlinear Circuits and Systems, Fundamentals of Radiophysics and Electronics, Theory of Signals and Theoretical Radiophysics, Theoretical Mechanics and Electrodynamics.

The book is designed for researchers, lecturers, post-graduate students and undergraduates at universities, academies, higher educational institutions, institutes and research centers, where radiophysical and physico-technical subjects are taught. The book can evoke interest in a broad circle of specialists: physicists and mechanicians, specialists in the Theory of nonlinear oscillations, in Radiophysics and Nonlinear Mechanics; engineers, specialists in Radioelectronics, Nonlinear radio engineering, Nonlinear electrical engineering, Microwave engineering, Automation and instrument engineering; specialists involved in Applied Mathematics and dealing with the Theory of nonlinear oscillations with applications in Radiophysics, Mechanics, Biocybernetics, etc.

The author appreciates highly his fertile joint work with Prof. Sc.D. N.D.Biryuk, (Voronezh State University, Russia) on the general analysis of the parametric phenomena in radiophysical systems, Dr.D.B.Duboshinsky and Dr.Y.B.Duboshinsky, (Vladimir Polytechnic Institute, Russia) on the phenomena of adaptive grouping of radiophysical and mechanical systems in stable formations, and Assoc. Prof. Dr. P.G.Georgiev, (Department of Physics, Technical University, Varna) on generator transformation of signals in radiophysical systems.

The author is particularly delighted to underscore the prolific sharing of expertise and ideas with Prof. V.Cimagalli (Rome University, Italy), Dr.A.Holden (Leeds University, UK), Prof. Z.Jasino (Montreal University, Canada), Prof. A. Bossavit (Electricité de France, Paris), Prof. A.Cronin (New Jersey University, USA), Prof. H.Hagedorn (Darmstadt Polytechnic University, Germany), Prof. H. Kawakami (Tokushima University, Japan), Prof. Sc.D. Y.L.Khotuntsev, (Moscow Polytechnic University, Moscow, Russia), Prof.M.Farkas (Budapest Polytechnic University, Hungary), Prof. J.Mavhin (Leuven University, Belgium), Prof. D.R.K. Sastry (Kondapur Research Centre, India), Prof. A.Tondal (National Machine

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The author expresses his gratitude to the authorities of the Space Research Institute at the Bulgarian Academy of Sciences for providing the environment needed and being able to insure the tests recorded in the book.

The author would like to thank the translator, Mrs. Mariana Stoycheva, the editors, Mrs. Anne-Marie De Grazia and Mrs. Katerina Spasova, and the computer operator Mr. Plamen Chavdarov for their helpful cooperation.

25th May, 2001 Vladimir DAMGOV
Sofia

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