

DYNAMICAL TRANSITION THEORY OF HEXAGONAL PATTERN FORMATIONS

TAYLAN SENGÜL

ABSTRACT. The main goal of this paper is to understand the formation of hexagonal patterns from the dynamical transition theory point of view. We consider the transitions from a steady state of an abstract nonlinear dissipative system. To shed light on the formation of mixed mode patterns such as the hexagonal pattern, we consider the case where the linearized operator of the system has two critical real eigenvalues, at a critical value λ_c of a control parameter λ with associated eigenmodes having a roll and rectangular pattern. By using center manifold reduction, we obtain the reduced equations of the system near the critical transition value λ_c . By a thorough analysis of these equations, we fully characterize all possible transition scenarios when the coefficients of the quadratic part of the reduced equations do not vanish. We consider three problems, two variants of the 2D Swift-Hohenberg equation and the 3D surface tension driven convection, to demonstrate that all the main theoretical results we obtain here are indeed realizable.

1. INTRODUCTION: MAIN ASSUMPTIONS AND RESULTS

Transition phenomena is throughout all nonlinear sciences [23, 16, 14]. It shapes many physical, biological and social systems through instabilities. The formation of patterns in such systems, whether it be coatings of animals [24], convection cells in fluid systems [1] or crime patterns in cities [35], is intrinsically related to the transitions taking place in those systems. One of the tools to understand and classify the transition behavior is the dynamic transition theory [23]. The current work is an attempt to combine this theory with certain aspects of pattern formations and relies on some of the previous work in this direction [10, 33, 34, 20].

1.1. The setting and the main assumptions. We are interested in the transitions of a steady state solution of a general nonlinear dissipative system [37] on a Hilbert space X

$$(1) \quad \frac{du}{dt} = L_\lambda u + G_\lambda(u), \quad t > 0$$

where $u : [0, \infty) \mapsto X$ is the unknown function and $\lambda \in \mathbb{R}^1$ is a parameter. Here $L_\lambda : X_1 \rightarrow X$ is a linear operator where X_1 is another

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Dynamical Theory Of Pattern Formation

Jordi Bascompte, Ricard V. Sole



Dynamical Theory Of Pattern Formation:

The Dynamics Of Pattern Alexander B Ezersky, Mikhail I Rabinovich, Patrick D Weidman, 2000-10-31 Spirals vortices crystalline lattices and other attractive patterns are prevalent in Nature How do such beautiful patterns appear from the initial chaos What universal dynamical rules are responsible for their formation What is the dynamical origin of spatial disorder in nonequilibrium media Based on the many visual experiments in physics hydrodynamics chemistry and biology this invaluable book answers those and related intriguing questions The mathematical models presented for the dynamical theory of pattern formation are nonlinear partial differential equations The corresponding theory is not so accessible to a wide audience Consequently the authors have made every attempt to synthesize long and complex mathematical calculations to exhibit the underlying physics The book will be useful for final year undergraduates but is primarily aimed at graduate students postdoctoral fellows and others interested in the puzzling phenomena of pattern formation [The Dynamics of Patterns](#) M. I. Rabinovich, A. B. Ezersky, Patrick D. Weidman, 2000 This beautifully illustrated book brings together a remarkable array of pattern forming phenomena The authors have assembled an impressive collection of striking photographs and computer generated images and the book would be worth buying for this alone the Appendix describing key experiments is a highlight Here the authors outline the historical development of experiments in parametrically excited patterns thermal convection and diffusive chemical reactions UK Nonlinear News 2002 **Patterns, Information and Chaos in Neuronal Systems** Bruce J. West, 1993 This is the second volume in a series intended to give clear expositions of the applications of the new techniques developed to understand nonlinear phenomena in the life sciences The first paper by West Mackey and Chen is methodological in nature and reviews how to distinguish between noise in biomedical data sets and irregularities generated by deterministic dynamical equations The second paper by Hock Sch ner Balz Eastman and Voss addresses the problem of pattern formation and pattern change in the vision system The authors emphasize the experimental correspondence between quantifiable perceptual phenomena and certain features of nonlinear dynamical systems theory The paper by Chay focuses on modeling strategies for biological phenomena that manifest strong nonlinear behavior Biological rhythms and electrical bursting phenomena are discussed in detail and certain apparently random processes are shown to be describable by chaos The final paper is an attempt by Nicolis and Katsikas to use nonlinear dynamics systems theory to develop a general theory of linguistics The concepts of information and pattern recognition are used in concert with that of a dynamic attractor to argue for the general properties of a cognitive processor [Synergetics and Dynamic Instabilities](#) G. Caglioti, L. Lugiato, H. Haken, 1988-01-01 This collection of papers presented at the Enrico Fermi School considers the subject of synergetics as a firmly established field of interdisciplinary research ranging from physics chemistry and biology to subjects like economy and sociology These proceedings focus on the natural sciences *Nonlinear Dynamics and Pattern Formation in the Natural Environment* A Doelman, A Van Harten, 2022-09-16 This Research Note aims to provide an insight

into recent developments in the theory of pattern formation In the last decade there has been considerable progress in this field both from a theoretical and a practical point of view Recent mathematical developments concern the study of the nonlinear stability of systems at near critical conditions by an appropriate system of modulation equations The complexity of the original problem can be reduced drastically by this approximation Moreover it provides unifying point of view for a wide range of problems New applications of the theory arise in a multitude of scientific areas such as hydrodynamics reaction diffusion problems oceanography meteorology combustion geophysical and biological morphodynamics and semi conductors This book is intended to show the interactions between the mathematical theory of nonlinear dynamics and the study of pattern generating phenomena in the natural environment There is an intimate relationship between new insights in the mathematical aspects of nonlinear pattern formation and the comprehension of such phenomena Therefore there are two partly overlapping main themes one in which the emphasis is on generally applicable mathematical theories and techniques and one in which the phenomenology of pattern evolution in various areas is discussed The book comprises 19 contributions by experts in the field Although the emphasis changes considerably from paper to paper in each contribution the same two themes are present all the authors have aimed to achieve a suitable balance between the mathematical theory and the physical phenomena

Ambiguity in Mind and Nature Peter Kruse, Michael Stadler, 2012-12-06 Ambiguity in Mind and Nature is the result of cognitive multistability the phenomenon in which an unchanging stimulus usually visual gives rise in the subject to an oscillating perceptual interpretation The vase face picture is one of the most famous examples In this book scientists from many disciplines including physics biology psychology maths and computer science present recent progress in this fascinating area of cognitive science Using the phenomenon of multistability as a paradigm they seek to understand how meaning originates in the brain as a consequence of cognitive processes New advances are achieved by applying concepts such as self organization chaos theory and complex systems to the latest results of psychological and neurophysical experiments

Bifurcation Theory and Spatio-Temporal Pattern Formation Wayne Nagata, Navaratnam Sri Namachchivaya, 2006-10-03 Nonlinear dynamical systems and the formation of spatio temporal patterns play an important role in current research on partial differential equations This book contains articles on topics of current interest in applications of dynamical systems theory to problems of pattern formation in space and time Topics covered include aspects of lattice dynamical systems convection in fluid layers with large aspect ratios mixed mode oscillations and canards bacterial remediation of waste gyroscopic systems data clustering and the second part of Hilbert s 16th problem Most of the book consists of expository survey material and so can serve as a source of convenient entry points to current research topics in nonlinear dynamics and pattern formation This volume arose from a workshop held at the Fields Institute in December of 2003 honoring Professor William F Langford s fundamental work on the occasion of his sixtieth birthday Information for our distributors Titles in this series are copublished with the Fields Institute for Research in Mathematical Sciences Toronto

Ontario Canada **Evolutionary Dynamics** James Patrick Crutchfield, Peter Schuster, 2003 The 14 chapters of this volume which present an overview of new research in evolutionary dynamics were first presented at a conference held in October 1998 at the Santa Fe Institute The main divisions of the book are macroevolution epochal evolution population genetics dynamics and optimization and evolution of cooperation Individual topics include spectral landscape theory external triggers in biological evolution and evolutionary dynamics of asexual reproduction Several of the contributors like the editors are affiliated with the Santa Fe Institute others teach or work in physics genetics biology computational neuroscience and theoretical chemistry at universities and private institutions in the US UK Austria Sweden Australia Israel and Germany
Annotation copyrighted by Book News Inc Portland OR **Dynamical Theory of Dendritic Growth in Convective Flow** Jian-Jun Xu, 2013-04-17 Convective flow in the liquid phase is always present in a realistic process of freezing and melting and may significantly affect the dynamics and results of the process The study of the interplay of growth and convection flow during the solidification has been an important subject in the broad fields of materials science condensed matter physics fluid physics micro gravity science etc The present book is concerned with the dynamics of free dendritic growth with convective flow in the melt It systematically presents the results obtained in terms of a unified asymptotic approach in the framework of the interfacial wave IFW theory In particular the book explores the effect of the various types of convection flow on the selection and pattern formation of dendritic growth based on the global stability analysis **Journal of the Physical Society of Japan** ,1998 **Dynamics and Patterns in Complex Fluids** Akira Ōnuki, Kyozi Kawasaki, 1990 **Pattern Formation and Dynamics in Nonequilibrium Systems** Michael Cross, Henry Greenside, 2009-07-16 An account of how complex patterns form in sustained nonequilibrium systems for graduate students in biology chemistry engineering mathematics and physics Journal of the Royal Society, Interface ,2005 **Chemical Abstracts** ,1922 *Lectures In The Sciences Of Complexity* Daniel L. Stein, 1989-01-21 *Nonlinear Dynamics of Production Systems* Günter Radons, Reimund Neugebauer, 2004 This reference work provides a comprehensive insight into the recent developments of applications of Nonlinear Dynamics in the field of production systems Applications range from manufacturing and process engineering to selected topics in mechanical engineering automation technology and plant management This compilation of contributions shows how methods of Nonlinear Dynamics can be used to solve problems arising in traditional or non conventional manufacturing techniques such as turning high speed milling laser welding jet cutting or electrochemical processing Recent progress in optimizing the dynamics of production lines and complete production systems is also covered The book addresses both experts in Nonlinear Dynamics who want to apply their methods to real world problems and practitioners who seek solutions for their engineering problems Neural Computation ,2003 Modeling Spatiotemporal Dynamics in Ecology Jordi Bascompte, Ricard V. Sole, 1998 Throughout its history ecology has largely been a descriptive science Scientists are in need of a theoretical framework that will assist in the understanding of observed patterns and will

serve as a predictive tool Since ecological systems are dynamic and spatially extended it is particularly important to understand the processes underlying spatiotemporal patterns This book reviews one of the newest and most important areas of theoretical ecology the study of spatiotemporal dynamics by means of a spatially explicit approximation that allows the investigation of the effects of real space Rendiconti della Scuola internazionale di fisica "Enrico Fermi." ,1988

General Biophysics Mikhail Vladimirovich Vol'kenshteĭn,1983

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