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Editors

# Numerical Methods for Bifurcation Problems and Large-Scale Dynamical Systems



Springer



# Numerical Methods For Bifurcation Problems

**Herbert Bishop Keller,A. K.  
Nandakumaran,Mythily Ramaswamy**





## **Numerical Methods For Bifurcation Problems:**

**Numerical Methods for Bifurcation Problems** T. Kupper, Hans D. Mittelman, H. Weber, 1984-07-01      **Numerical Methods for Bifurcation Problems and Large-Scale Dynamical Systems** Eusebius Doedel, Laurette S. Tuckerman, 2012-12-06 The Institute for Mathematics and its Applications IMA devoted its 1997 1998 program to Emerging Applications of Dynamical Systems Dynamical systems theory and related numerical algorithms provide powerful tools for studying the solution behavior of differential equations and mappings In the past 25 years computational methods have been developed for calculating fixed points limit cycles and bifurcation points A remaining challenge is to develop robust methods for calculating more complicated objects such as higher codimension bifurcations of fixed points periodic orbits and connecting orbits as well as the calculation of invariant manifolds Another challenge is to extend the applicability of algorithms to the very large systems that result from discretizing partial differential equations Even the calculation of steady states and their linear stability can be prohibitively expensive for large systems e g  $10^3$   $10^6$  equations if attempted by simple direct methods Several of the papers in this volume treat computational methods for low and high dimensional systems and in some cases their incorporation into software packages A few papers treat fundamental theoretical problems including smooth factorization of matrices self organized criticality and unfolding of singular heteroclinic cycles Other papers treat applications of dynamical systems computations in various scientific fields such as biology chemical engineering fluid mechanics and mechanical engineering      **Numerical Methods for Bifurcation Problems** KÜPPER, MITTELMANN, WEBER, 2013-11-27      **Continuation Techniques and Bifurcation Problems** MITTELMANN, FISCHER, 2013-11-21 The analysis of parameter dependent nonlinear has received much attention in recent years Numerical continuation techniques allow the efficient computation of solution branches in a one parameter problem In many cases continuation procedures are used as part of a more complete analysis of a nonlinear problem based on bifurcation theory and singularity theory These theories contribute to the understanding of many nonlinear phenomena in nature and they form the basis for various analytical and numerical tools which provide qualitative and quantitative results about nonlinear systems In this issue we have collected a number of papers dealing with continuation techniques and bifurcation problems Readers familiar with the notions of continuation and bifurcation will find recent research results addressing a variety of aspects in this issue Those who intend to learn about the field or a specific topic in it may find it useful to first consult earlier literature on the numerical treatment of these problems together with some theoretical background The papers in this issue fall naturally into different groups      Lectures on Numerical Methods in Bifurcation Problems Herbert Bishop Keller, A. K. Nandakumaran, Mythily Ramaswamy, 1987      *Continuation and Bifurcations: Numerical Techniques and Applications* Dirk Roose, Bart De Dier, Alastair Spence, 2012-12-06 Proceedings of the NATO Advanced Research Workshop Leuven Belgium September 18 22 1989      Bifurcation Problems and their Numerical Solution



H. D. Mittelman, H. Weber, 2013-11-21 *Numerical Methods for Bifurcations of Dynamical Equilibria* Willy J. F. Govaerts, 2000-01-01 Numerical methods for the detection computation and continuation of equilibria and bifurcation points of equilibria of dynamical systems **Numerical Methods of Bifurcation Problems Via Singular Value Decompositions and Homotopy Methods** Yun-qi Shen, 1988 *Lectures on numerical methods in bifurcation problems* Herbert B. Keller, 1987 **Lectures on Numerical Methods in Bifurcation Problems** Herbert Bishop Keller, A. K. Nandakumaran, Indian Institute of Science, Bangalore, Mythily Ramaswamy, 1987 *Numerical Continuation Methods for Dynamical Systems* Bernd Krauskopf, Hinke M. Osinga, Jorge Galan-Vioque, 2007-11-06 Path following in combination with boundary value problem solvers has emerged as a continuing and strong influence in the development of dynamical systems theory and its application It is widely acknowledged that the software package AUTO developed by Eusebius J Doedel about thirty years ago and further expanded and developed ever since plays a central role in the brief history of numerical continuation This book has been compiled on the occasion of Sebius Doedel s 60th birthday Bringing together for the first time a large amount of material in a single accessible source it is hoped that the book will become the natural entry point for researchers in diverse disciplines who wish to learn what numerical continuation techniques can achieve The book opens with a foreword by Herbert B Keller and lecture notes by Sebius Doedel himself that introduce the basic concepts of numerical bifurcation analysis The other chapters by leading experts discuss continuation for various types of systems and objects and showcase examples of how numerical bifurcation analysis can be used in concrete applications Topics that are treated include interactive continuation tools higher dimensional continuation the computation of invariant manifolds and continuation techniques for slow fast systems for symmetric Hamiltonian systems for spatially extended systems and for systems with delay Three chapters review physical applications the dynamics of a SQUID global bifurcations in laser systems and dynamics and bifurcations in electronic circuits Numerical Bifurcation Analysis for Reaction-Diffusion Equations Zhen Mei, 2000-06-21 This monograph is the first to provide readers with numerical tools for a systematic analysis of bifurcation problems in reaction diffusion equations Many examples and figures illustrate analysis of bifurcation scenario and implementation of numerical schemes Readers will gain a thorough understanding of numerical bifurcation analysis and the necessary tools for investigating nonlinear phenomena in reaction diffusion equations Computational Methods in Bifurcation Theory and Dissipative Structures M. Kubicek, M. Marek, 2012-12-06 Dissipative structures is a concept which has recently been used in physics to discuss the formation of structures organized in space and or time at the expense of the energy flowing into the system from the outside The space time structural organization of biological systems starting from the subcellular level up to the level of ecological systems coherent structures in laser and of elastic stability in mechanics instability in hydro plasma physics problems dynamics leading to the development of turbulence behavior of electrical networks and chemical reactors form just a short list of problems treated in this framework Mathematical models



constructed to describe these systems are usually nonlinear often formed by complicated systems of algebraic ordinary differential or partial differential equations and include a number of characteristic parameters In problems of theoretical interest as well as engineering practice we are concerned with the dependence of solutions on parameters and particularly with the values of parameters where qualitatively new types of solutions e g oscillatory solutions new stationary states and chaotic attractors appear bifurcate Numerical techniques to determine both bifurcation points and the dependence of steady state and oscillatory solutions on parameters are developed and discussed in detail in this text The text is intended to serve as a working manual not only for students and research workers who are interested in dissipative structures but also for practicing engineers who deal with the problems of constructing models and solving complicated nonlinear systems

*Numerical Methods for Bifurcation Problems* Hans Detlef Mittelman, Helmut Weber, 1980      **Bifurcation and Symmetry** BÖHMER, ALLGOWER, GOLUBITSKY, 2013-03-08 Symmetry is a property which occurs throughout nature and it is therefore natural that symmetry should be considered when attempting to model nature In many cases these models are also nonlinear and it is the study of nonlinear symmetric models that has been the basis of much recent work Although systematic studies of nonlinear problems may be traced back at least to the pioneering contributions of Poincare this remains an area with challenging problems for mathematicians and scientists Phenomena whose models exhibit both symmetry and nonlinearity lead to problems which are challenging and rich in complexity beauty and utility In recent years the tools provided by group theory and representation theory have proven to be highly effective in treating nonlinear problems involving symmetry By these means highly complex situations may be decomposed into a number of simpler ones which are already understood or are at least easier to handle In the realm of numerical approximations the systematic exploitation of symmetry via group representation theory is even more recent In the hope of stimulating interaction and acquaintance with results and problems in the various fields of applications bifurcation theory and numerical analysis we organized the conference and workshop Bifurcation and Symmetry Cross Influences between Mathematics and Applications during June 27 8 14 1991 at the Philipps University of Marburg Germany      **Bifurcation Analysis of Fluid Flows** Henk A. Dijkstra, Fred W. Wubs, 2023-08-24 A better understanding of the mechanisms leading a fluid system to exhibit turbulent behavior is one of the grand challenges of the physical and mathematical sciences Over the last few decades numerical bifurcation methods have been extended and applied to a number of flow problems to identify critical conditions for fluid instabilities to occur This book provides a state of the art account of these numerical methods with much attention to modern linear systems solvers and generalized eigenvalue solvers These methods also have a broad applicability in industrial environmental and astrophysical flows The book is a must have reference for anyone working in scientific fields where fluid flow instabilities play a role Exercises at the end of each chapter and Python code for the bifurcation analysis of canonical fluid flow problems provide practice material to get to grips with the methods and concepts presented in the book      Bifurcation: Analysis,



Algorithms, Applications KÜPPER, SEYDEL, TROGER, 2013-03-08 The conference on BIFURCATIONS ANALYSIS ALGORITHMS APPLICATIONS took place in Dortmund in August 18-22 1986 More than 150 Scientists from 16 countries participated in the meeting among them mathematicians engineers and physicists A broad spectrum of new results on bifurcation was covered by 49 talks The diversity of the range of treated topics and of involved fields inspired fruitful discussions 36 refereed papers are contained in these proceedings The subjects covered treat bifurcation problems ranging from theoretical investigations to numerical results with emphasis placed upon applications The more theoretical papers include the topics symmetry breaking delay differential equations Cornu spirals homoclinic orbits and selfsimilarity Different kinds of bifurcations are treated Hopf bifurcation bifurcation from continuous spectrum complex bifurcation and bifurcation near tori Several numerical aspects are discussed among them continuation block elimination and spectral methods Algorithms are proposed for approximating manifolds calculating periodic solutions and handling multi parameter problems Ample space is devoted to applications Classical phenomena from fluid mechanics such as convection rolls and the Taylor vortex problem buckling and reaction diffusion problems are considered Other applications of bifurcations include railway vehicle dynamics computer graphics semiconductors drilling processes simulation of oil reservoirs and rotor dynamics The proceedings reflect current research in bifurcation They are an attempt to bring together researchers from different disciplines to stimulate common effort towards a better understanding and handling of bifurcation problems

*Computational Modelling of Bifurcations and Instabilities in Fluid Dynamics* Alexander Gelfgat, 2018-07-06 Instabilities of fluid flows and the associated transitions between different possible flow states provide a fascinating set of problems that have attracted researchers for over a hundred years This book addresses state of the art developments in numerical techniques for computational modelling of fluid instabilities and related bifurcation structures as well as providing comprehensive reviews of recently solved challenging problems in the field

**Numerical Continuation and Bifurcation in Nonlinear PDEs** Hannes Uecker, 2021-08-19 This book provides a hands on approach to numerical continuation and bifurcation for nonlinear PDEs in 1D 2D and 3D Partial differential equations PDEs are the main tool to describe spatially and temporally extended systems in nature PDEs usually come with parameters and the study of the parameter dependence of their solutions is an important task Letting one parameter vary typically yields a branch of solutions and at special parameter values new branches may bifurcate After a concise review of some analytical background and numerical methods the author explains the free MATLAB package pde2path by using a large variety of examples with demo codes that can be easily adapted to the reader's given problem Numerical Continuation and Bifurcation in Nonlinear PDEs will appeal to applied mathematicians and scientists from physics chemistry biology and economics interested in the numerical solution of nonlinear PDEs particularly the parameter dependence of solutions It can be used as a supplemental text in courses on nonlinear PDEs and modeling and bifurcation



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