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Numerical Methods for Bifurcation Problems and Large-Scale Dynamical Systems

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Numerical Methods For Bifurcation Problems And Large Scale Dynamical Systems

Eugene L. Allgower,Kurt Georg

Numerical Methods For Bifurcation Problems And Large Scale Dynamical Systems:

Numerical Methods for Bifurcation Problems and Large-Scale Dynamical Systems Eusebius Doedel,Laurette S Tuckerman,2000-03-17 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 calcuation 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 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 Methods for Bifurcation Problems and Large-scale

Dynamical Systems Eusebius Doedel,Laurette S. Tuckerman,2000 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 calcuation 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 theoreti **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 *Towards Higher Categories* John C. Baez,J. Peter May,2009-09-24 The purpose of this book is to give background for those who would like to delve into some higher category theory It is not a primer on higher category theory itself It begins with a paper by John Baez and Michael Shulman which explores informally by analogy and direct connection how cohomology and other tools of algebraic topology are seen through the eyes of n category theory The idea is to give some of the motivations behind this subject There are then two survey articles by Julie Bergner and Simona Paoli about infinity 1 categories and about the algebraic modelling of homotopy n types These are areas that are particularly well understood and where a fully integrated theory exists The main focus of the book is on the richness to be found in the theory of bicategories which gives the essential starting point towards the understanding of higher categorical structures An article by Stephen Lack gives a thorough but informal guide to this theory A paper by Larry Breen on the theory of gerbes shows how such categorical structures appear in differential geometry This book is dedicated to Max Kelly the founder of the Australian school of category theory and an historical paper by Ross Street describes its development **Ergodic Theory, Analysis, and Efficient Simulation of Dynamical Systems** Bernold Fiedler,2012-12-06 This book summarizes and highlights progress in our understanding of Dy namical Systems during six years of the German Priority Research Program Ergodic Theory Analysis and Efficient Simulation of Dynamical Systems The program was funded by the Deutsche Forschungsgemeinschaft DFG and aimed at combining focussing and enhancing research efforts of active groups in the field by cooperation on a federal level The surveys in the

book are addressed to experts and non experts in the mathematical community alike In addition they intend to convey the significance of the results for applications far into the neighboring disciplines of Science Three fundamental topics in Dynamical Systems are at the core of our research effort behavior for large time dimension measure and chaos Each of these topics is of course a highly complex problem area in itself and does not fit naturally into the deplorably traditional confines of any of the disciplines of ergodic theory analysis or numerical analysis alone The necessity of mathematical cooperation between these three disciplines is quite obvious when facing the formidahle task of establishing a bidirectional transfer which bridges the gap between deep detailed theoretical insight and relevant specific applications Both analysis and numerical analysis playa key role when it comes to huilding that bridge Some steps of our joint bridging efforts are collected in this volume Neither our approach nor the presentations in this volume are monolithic 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 **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 *Atmospheric Modeling* David P. Chock,Gregory R. Carmichael,2002-07-31 This volume contains refereed papers submitted by international experts who participated in the Atmospheric Modeling workshop March 15 19 2000 at the Institute for Mathematics and Its Applications IMA at the University of Minnesota The papers cover a wide range of topics presented in the workshop In

particular mathematical topics include a performance comparison of operator splitting and non splitting methods time stepping methods to preserve positivity and consideration of multiple timescale issues in the modeling of atmospheric chemistry a fully 3D adaptive grid method impact of rid resolution on model predictions testing the robustness of different flow fields modeling and numerical methods in four dimensional variational data assimilation and parallel computing Modeling topics include the development of an efficient self contained global circulation chemistry transport model and its applications the development of a modal aerosol model and the modeling of the emissions and chemistry of monoterpenes that lead to the formation of secondary organic aerosols The volume provides an excellent cross section of current research activities in atmospheric modeling **Modern Methods in Scientific Computing and Applications** Anne Bourlioux,Martin Gander,2012-12-06 When we first heard in the spring of 2000 that the Seminaire de matMmatiques superieures SMS was interested in devoting its session of the summer of 200l its 40th to scientific computing the idea of taking on the organizational work seemed to us somewhat remote More immediate things were on our minds one of us was about to go on leave to the Courant Institute the other preparing for a research summer in Paris But the more we learned about the possibilities of such a seminar the support for the organization and also the great history of the SMS the more we grew attached to the project The topics we planned to cover were intended to span a wide range of theoretical and practical tools for solving problems in image processing thin films mathematical finance electrical engineering moving interfaces and combustion These applications alone show how wide the influence of scientific computing has become over the last two decades almost any area of science and engineering is greatly influenced by simulations and the SMS workshop in this field came very timely We decided to organize the workshop in pairs of speakers for each of the eight topics we had chosen and we invited the leading experts worldwide in these fields We were very fortunate that every speaker we invited accepted to come so the program could be realized as planned *Nonlinear Conservation Laws and Applications* Alberto Bressan,Gui-Qiang G. Chen,Marta Lewicka,Dehua Wang,2011-04-19 This volume contains the proceedings of the Summer Program on Nonlinear Conservation Laws and Applications held at the IMA on July 13 31 2009 Hyperbolic conservation laws is a classical subject which has experienced vigorous growth in recent years The present collection provides a timely survey of the state of the art in this exciting field and a comprehensive outlook on open problems Contributions of more theoretical nature cover the following topics global existence and uniqueness theory of one dimensional systems multidimensional conservation laws in several space variables and approximations of their solutions mathematical analysis of fluid motion stability and dynamics of viscous shock waves singular limits for viscous systems basic principles in the modeling of turbulent mixing transonic flows past an obstacle and a fluid dynamic approach for isometric embedding in geometry models of nonlinear elasticity the Monge problem and transport equations with rough coefficients In addition there are a number of papers devoted to applications These include models of blood flow self gravitating compressible fluids granular flow charge

transport in fluids and the modeling and control of traffic flow on networks Emerging Frontiers in Nonlinear Science Panayotis G. Kevrekidis,Jesús Cuevas-Maraver,Avadh Saxena,2020-05-29 This book explores the impact of nonlinearity on a broad range of areas including time honored fields such as biology geometry and topology but also modern ones such as quantum mechanics networks metamaterials and artificial intelligence The concept of nonlinearity is a universal feature in mathematics physics chemistry and biology and is used to characterize systems whose behavior does not amount to a superposition of simple building blocks but rather features complex and often chaotic patterns and phenomena Each chapter of the book features a synopsis that not only recaps the recent progress in each field but also charts the challenges that lie ahead This interdisciplinary book presents contributions from a diverse group of experts from various fields to provide an overview of each field s past present and future It will appeal to both beginners and seasoned researchers in nonlinear science numerous areas of physics optics quantum physics biophysics and applied mathematics ODEs PDEs dynamical systems machine learning as well as engineering *Sixth IUTAM Symposium on Laminar-Turbulent Transition* Rama Govindarajan,2006-01-18 The dynamics of transition from laminar to turbulent flow remains to this day a major challenge in theoretical and applied mechanics A series of IUTAM symposia held over the last twenty five years at well known Centres of research in the subject Novosibirsk Stuttgart Toulouse Sendai and Sedona Arizona has proved to be a great catalyst which has given a boost to research and our understanding of the field At this point of time the field is changing significantly with several emerging directions The sixth IUTAM meeting in the series which was held at the Jawaharlal Nehru Centre for Advanced Scientific Research Bangalore India focused on the progress after the fifth meeting held at Sedona in 1999 The s posium which adhered to the IUTAM format of a single session included seven invited lectures fifty oral presentations and eight posters During the course of the symposium the following became evident The area of laminar turbulent transition has progressed considerably since 1999 Better theoretical tools for handling nonlinearities as well as transient behaviour are now available This is accompanied by an en mous increase in the level of sophistication of both experiments and direct numerical simulations The result has been that our understanding of the early stages of the transition process is now on much firmer footing and we are now able to study many aspects of the later stages of the transition process **Parallel Solution of Partial Differential Equations** Petter Bjorstad,Mitchell Luskin,2012-12-06 This IMA Volume in Mathematics and its Applications PARALLEL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS is based on the proceedings of a workshop with the same title The work shop was an integral part of the 1996 97IMA program on MATHEMAT ICS IN HIGH PERFORMANCE COMPUTING I would like to thank Petter Bj0rstad of the Institutt for Informatikk University of Bergen and Mitchell Luskin of the School of Mathematics University of Minnesota for their excellent work as organizers of the meeting and for editing the proceedings I also take this opportunity to thank the National Science Founda tion NSF Department of Energy DOE and the Army Research Office ARO whose financial support made the workshop possible Willard Miller Jr

Professor and Director v PREFACE The numerical solution of partial differential equations has been of major importance to the development of many technologies and has been the target of much of the development of parallel computer hardware and software Parallel computers offer the promise of greatly increased perfor mance and the routine calculation of previously intractable problems The papers in this volume were presented at the IMA workshop on the Paral lel Solution of PDE held during June 9 13 1997 The workshop brought together leading numerical analysts computer scientists and engineers to assess the state of the art and to consider future directions *Methods of Qualitative Theory in Nonlinear Dynamics* L. P. Shil'nikov,2001 Bifurcation and chaos has dominated research in nonlinear dynamics for over two decades and numerous introductory and advanced books have been published on this subject There remains however a dire need for a textbook which provides a pedagogically appealing yet rigorous mathematical bridge between these two disparate levels of exposition This book has been written to serve that unfulfilled need Following the footsteps of Poincar r and the renowned Andronov school of nonlinear oscillations this book focuses on the qualitative study of high dimensional nonlinear dynamical systems Many of the qualitative methods and tools presented in the book have been developed only recently and have not yet appeared in textbook form In keeping with the self contained nature of the book all the topics are developed with introductory background and complete mathematical rigor Generously illustrated and written at a high level of exposition this invaluable book will appeal to both the beginner and the advanced student of nonlinear dynamics interested in learning a rigorous mathematical foundation of this fascinating subject Sample Chapter s Introduction to Part II 124 KB Chapter 7 1 Rough systems on a plane Andronov Pontryagin theorem 218 KB Chapter 7 2 The set of center motions 158 KB Chapter 7 3 General classification of center motions 155 KB Chapter 7 4 Remarks on roughness of high order dynamical systems 136 KB Chapter 7 5 Morse Smale systems 435 KB Chapter 7 6 Some properties of Morse Smale systems 211 KB Contents Structurally Stable Systems Bifurcations of Dynamical Systems The Behavior of Dynamical Systems on Stability Boundaries of Equilibrium States The Behavior of Dynamical Systems on Stability Boundaries of Periodic Trajectories Local Bifurcations on the Route Over Stability Boundaries Global Bifurcations at the Disappearance of a Saddle Node Equilibrium States and Periodic Orbits Bifurcations of Homoclinic Loops of Saddle Equilibrium States Safe and Dangerous Boundaries Readership Engineers students mathematicians and researchers in nonlinear dynamics and dynamical systems *Mathematical Reviews* ,2005 **IUTAM Symposium on Flow Control and MEMS** Jonathan F. Morrison,D. M. Birch,P. Lavoie,2010-09-09 The Symposium brought together many of the world s experts in fluid mechanics microfabrication and control theory to discover the synergy that can lead to real advances and perhaps find ways in which collaborative projects may proceed The high profile meeting was attended by keynote speakers who are leaders in their fields A key driver was the improvement in flow efficiency to reduce drag and thereby emissions arising from transport About 65 papers were presented Introduction to Numerical Continuation Methods Eugene L. Allgower,Kurt Georg,2003-01-01 Numerical continuation

methods have provided important contributions toward the numerical solution of nonlinear systems of equations for many years The methods may be used not only to compute solutions which might otherwise be hard to obtain but also to gain insight into qualitative properties of the solutions Introduction to Numerical Continuation Methods originally published in 1979 was the first book to provide easy access to the numerical aspects of predictor corrector continuation and piecewise linear continuation methods Not only do these seemingly distinct methods share many common features and general principles they can be numerically implemented in similar ways Introduction to Numerical Continuation Methods also features the piecewise linear approximation of implicitly defined surfaces the algorithms of which are frequently used in computer graphics mesh generation and the evaluation of surface integrals *Seventh IUTAM Symposium on Laminar-Turbulent Transition* Philipp Schlatter,Dan S. Henningson,2010-03-11 The origins of turbulent ow and the transition from laminar to turbulent ow are the most important unsolved problems of uid mechanics and aerodynamics sides being a fundamental question of uid mechanics there are numerous app cations relying on information regarding transition location and the details of the subsequent turbulent ow For example the control of transition to turbulence is pecially important in 1 skin friction reduction of energy ef cient aircraft 2 the performance of heat exchangers and diffusers 3 propulsion requirements for personic aircraft and 4 separation control While considerable progress has been made in the science of laminar to turbulent transition over the last 30 years the c tinuing increase in computer power as well as new theoretical developments are now revolutionizing the area It is now starting to be possible to move from simple 1D eigenvalue problems in canonical ows to global modes in complex ows all companied by accurate large scale direct numerical simulations DNS Here novel experimental techniques such as modern particle image velocimetry PIV also have an important role Theoretically the in uence of non normality on the stability and transition is gaining importance in particular for complex ows At the same time the enigma of transition in the oldest ow investigated Reynolds pipe ow tran tion experiment is regaining attention Ideas from dynamical systems together with DNS and experiments are here giving us new insights

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