Numerical Analysis Of Spectral Methods Theory And Applications Cbms Nsf Regional Conference Series In Applied Mathematics

ESCOBAR URIEL

Numerical Methods Springer Science & Business Media
This book focuses on the constructive and practical aspects of spectral methods. It rigorously examines the most important qualities as well as drawbacks of spectral methods in the context of numerical methods devoted to solve non-standard eigenvalue problems. In addition, the book also considers some nonlinear singularly perturbed boundary value problems along with eigenproblems obtained by their linearization around constant solutions. The book is mathematical, poising problems in their proper function spaces, but its emphasis is on algorithms and practical difficulties. The range of applications is quite large. High order eigenvalue problems are frequently beset with numerical ill conditioning problems. The book describes a wide variety of successful modifications to standard algorithms that greatly mitigate these problems. In addition, the book makes heavy use of the concept of pseudospectrum, which is highly relevant to understanding when disaster is imminent in solving eigenvalue problems. It also envisions two classes of applications, the stability of some elastic structures and the hydrodynamic stability of some parallel shear flows. This book is an ideal reference text for professionals (researchers) in applied mathematics, computational physics and engineering. It will be very useful to numerically sophisticated engineers, physicists and chemists. The book can also be used as a textbook in review courses such as numerical analysis, computational methods in various engineering branches or physics and computational methods in analysis.

Design, Analysis, and Computer Implementation of Algorithms Princeton University Press
Spectral Methods Using Multivariate Polynomials on the Unit Ball is a research level text on a numerical method for the solution of partial differential equations. The authors introduce, illustrate with examples, and analyze 'spectral methods' that are based on multivariate polynomial approximations. The method presented is an alternative to finite element and difference methods for regions that are diffeomorphic to the unit disk, in two dimensions, and the unit ball, in three dimensions. The speed of convergence of spectral methods is usually much higher than that of finite element or finite difference methods. Features Introduces the use of multivariate polynomials for the construction and analysis of spectral methods for linear and nonlinear boundary value problems Suitable for researchers and students in numerical analysis of PDEs, along with anyone interested in applying this method to a particular physical problem One of the few texts to address this area using multivariate orthogonal polynomials, rather than tensor products of univariate polynomials.

Theory and Applications John Wiley & Sons
This book presents the basic algorithms, the main theoretical results, and some applications of spectral methods. Particular attention is paid to the applications of spectral methods to nonlinear problems arising in fluid dynamics, quantum mechanics, weather prediction, heat conduction and other fields.The book consists of three parts. The first part deals with orthogonal approximations in Sobolev spaces and the stability and convergence of approximations for nonlinear problems, as the mathematical foundation of spectral methods. In the second part, various spectral methods are

described, with some applications. It includes Fourier spectral method, Legendre spectral method, Chebyshev spectral method, spectral penalty method, spectral vanishing viscosity method, spectral approximation of isolated solutions, multi-dimensional spectral method, spectral method for high-order equations, spectral-domain decomposition method and spectral multigrid method. The third part is devoted to some recent developments of spectral methods, such as mixed spectral methods, combined spectral methods and spectral methods on the surface.

Spectral Methods for Uncertainty Quantification SIAM

Handbook of Numerical Methods for Hyperbolic Problems explores the changes that have taken place in the past few decades regarding literature in the design, analysis and application of various numerical algorithms for solving hyperbolic equations. This volume provides concise summaries from experts in different types of algorithms, so that readers can find a variety of algorithms under different situations and readily understand their relative advantages and limitations. Provides detailed, cutting-edge background explanations of existing algorithms and their analysis Ideal for readers working on the theoretical aspects of algorithm development and its numerical analysis Presents a method of different algorithms for specific applications and the relative advantages and limitations of different algorithms for engineers or readers involved in applications Written by leading subject experts in each field who provide breadth and depth of content coverage

Numerical Analysis of Partial Differential Equations Springer Science & Business Media

The purpose of the book is to provide a rigorous treatment of spectral analysis using Fourier-based techniques in the geosciences, specifically geodesy and geophysics that deal with global and regional spatial data. The basic motivation is to get students to think about spatial data in the corresponding spectral domain. As such, the book emphasizes spatial-frequency analysis for data on the plane and sphere. Most books in spectral analysis develop the topic for time signals and are oriented to electrical and communications engineering. There are very few books for the spatial domain, which develop methods in two dimensions on the plane or the sphere for geodetic and geophysical applications. In the modern era of satellite remote sensing, these techniques are particularly important, as space-borne sensors generate global data (gravity, magnetics, topography, sea level, etc.). The proposed book includes applications to stochastic processes on the plane and sphere, which are important for many estimation problems that are based on some kind of stochastic constraints in inverse theory. There is a final chapter that briefly outlines wavelet analysis. Although a bit outside the scope, it is included to illustrate the contrast to traditional spectral analysis, going more toward a time-frequency analysis. For example, some applications such as wavelet-denoising, as opposed to low-pass filtering, are considered important supplements to the usual spectral methods. This book does not compete with the plethora of recent books on Spatial Data Analysis, which typically do not develop methods in the spectral domain. There are a few books on spectral methods in geophysics (none in geodesy) with which this book might compete. However, those books tend to emphasize specific applications, such as seismology or meteorology, rather than more general spatial signals on the plane and sphere. What this proposed book offers is more fundamental in this respect, and thus offers unique perspective for students in the geosciences.

Numerical Analysis of Spectral Methods SIAM

A unified discussion of the formulation and analysis of special methods of mixed initial boundary-value problems. The focus is on the development of a new mathematical theory that explains why and how well spectral methods work. Included are interesting extensions of the classical numerical analysis.

Spectral Methods for Time-Dependent Problems Now Publishers Inc

In this monograph we apply scattering theory methods to calculations in quantum ?eld theory, with a particular focus on properties of the quantum vacuum. These methods will provide e?cient and reliable solutions to a - riety of problems in quantum ?eld theory. Our approach will also elucidate in a concrete context many of the subtleties of quantum ?eld theory, such as divergences, regularization, and renormalization, by connecting them to more familiar results in quantum mechanics. We will use tools of scattering theory to characterize the spectrum of energyeigenstatesinapotentialbackground,hencethetermspectralmethods. This mode spectrum comprises both discrete bound states and a continuum of scattering states. We develop a powerful formalism that parameterizes the e?ects of the continuum by the density of states, which we compute from scattering data. Summing the zero-point energies of these modes gives the energy of the quantum vacuum, which is one of the central quantities we study.Althoughthemostcommonlystudiedbackgroundpotentialsarisefrom static soliton solutions to the classical equations of motion, these methods are not limited to such cases.

Spectral/hp Element Methods for Computational Fluid Dynamics John Wiley & Sons

Since the original publication of this book, available computer power has increased greatly. Today, scientific computing is playing an ever more prominent role as a tool in scientific discovery and engineering analysis. In this second edition, the key addition is an introduction to the finite element method. This is a widely used technique for solving partial differential equations (PDEs) in complex domains. This text introduces numerical methods and shows how to develop, analyse, and use them. Complete MATLAB programs for all the worked examples are now available at www.cambridge.org/Moin, and more than 30 exercises have been added. This thorough and practical book is intended as a first course in numerical analysis, primarily for new graduate students in engineering and physical science. Along with mastering the fundamentals of numerical methods, students will learn to write their own computer programs using standard numerical methods.

Spectral Methods Using Multivariate Polynomials On The Unit Ball CRC Press

This book explains how to solve partial differential equations numerically using single and multidomain spectral methods. It shows how only a few fundamental algorithms form the building blocks of any spectral code, even for problems with complex geometries.

Mathematics and the Aesthetic Springer Science & Business Media

A rigorous and comprehensive introduction to numerical analysis Numerical Methods provides a clear and concise exploration of standard numerical analysis topics, as well as nontraditional ones, including mathematical modeling, Monte Carlo methods, Markov chains, and fractals. Filled with appealing examples that will motivate students, the textbook considers modern application areas, such as information retrieval and animation, and classical topics from physics and engineering. Exercises use MATLAB and promote understanding of computational results. The book gives instructors the flexibility to emphasize different aspects—design, analysis, or computer implementation—of numerical algorithms, depending on the background and interests of students. Designed for upper-division undergraduates in mathematics or computer science classes, the textbook assumes that students have prior knowledge of linear algebra and calculus, although these topics are reviewed in the text. Short discussions of the history of numerical methods are interspersed throughout the chapters. The book also includes polynomial interpolation at Chebyshev points, use of the MATLAB package Chebfun, and a section on the fast Fourier transform. Supplementary materials are available online. Clear and concise exposition of standard numerical analysis topics Explores nontraditional topics, such as mathematical modeling and Monte Carlo methods Covers modern applications, including information retrieval and animation, and classical applications from physics and engineering Promotes understanding of computational results through MATLAB exercises Provides flexibility so instructors can emphasize mathematical or applied/computational aspects of numerical methods or a combination Includes recent results on polynomial interpolation at Chebyshev points and use of the MATLAB package Chebfun Short discussions of the history of numerical methods interspersed throughout Supplementary materials available online

CRC Press

Bringing together 18 chapters written by leading experts indynamical systems, operator theory, partial differential equations,and solid and fluid mechanics, this book presents state-of-the-artapproaches to a wide spectrum of new and challenging stabilityproblems. Nonlinear Physical Systems: Spectral Analysis, Stability andBifurcations focuses on problems of spectral analysis, stabilityand bifurcations arising in the nonlinear partial differentialequations of modern physics. Bifurcations and stability of solitarywaves, geometrical optics stability analysis in hydro-andmagnetohydrodynamics, and dissipation-induced instabilities aretreated with the use of the theory of Krein and Pontryagin space,index theory, the theory of multi-parameter eigenvalue problems andmodern asymptotic and perturbative approaches. Each chapter contains mechanical and physical examples, and thecombination of advanced material and more tutorial elements makesthis book attractive for both experts and non-specialists keen toexpand their knowledge on modern methods and trends in stabilitytheory. Contents 1. Surprising Instabilities of Simple Elastic Structures, DavideBigoni, Diego Misseroni, Giovanni Noselli and DanieleZaccaria. 2. WKB Solutions Near an Unstable Equilibrium and Applications,Jean-François Bony, Setsuro Fujiié, Thierry Ramond andMaher Zerzeri, partially supported by French ANR projectNOSEVOL. 3. The Sign Exchange Bifurcation in a Family of Linear HamiltonianSystems, Richard Cushman, Johnathan Robbins and DimitriiSadovskii. 4. Dissipation Effect on Local and Global Fluid-ElasticInstabilities, Olivier Doaré. 5. Tunneling, Librations and Normal Forms in a Quantum Double Wellwith a Magnetic Field, Sergey Yu. Dobrokhotov and Anatoly Yu.Anikin. 6. Stability of Dipole Gap Solitons in Two-Dimensional LatticePotentials, Nir Dror and Boris A. Malomed. 7. Representation of Wave Energy of a Rotating Flow in Terms of theDispersion Relation, Yasuhide Fukumoto, Makoto Hirota and YouichiMie. 8. Determining the Stability Domain of Perturbed Four-DimensionalSystems in 1:1 Resonance, Igor Hoveijn and Oleg N. Kirillov. 9. Index Theorems for Polynomial Pencils, Richard Kollár andRadomír Bosák. 10. Investigating Stability and Finding New Solutions inConservative Fluid Flows Through Bifurcation Approaches, PaoloLuzzatto-Fegiz and Charles H.K. Williamson. 11. Evolution Equations for Finite Amplitude Waves in ParallelShear Flows, Sherwin A. Maslowe. 12. Continuum Hamiltonian Hopf Bifurcation I, Philip J. Morrisonand George I. Hagstrom. 13. Continuum Hamiltonian Hopf Bifurcation II, George I. Hagstromand Philip J. Morrison. 14. Energy Stability Analysis for a Hybrid Fluid-Kinetic PlasmaModel, Philip J. Morrison, Emanuele Tassi and Cesare Tronci. 15. Accurate Estimates for the Exponential Decay of Semigroups withNon-Self-Adjoint Generators, Francis Nier. 16. Stability Optimization for Polynomials and Matrices, Michael L.Overton. 17. Spectral Stability of Nonlinear Waves in KdV-Type EvolutionEquations, Dmitry E. Pelinovsky. 18. Unfreezing Casimir Invariants: Singular Perturbations GivingRise to Forbidden Instabilities, Zensho Yoshida and Philip J.Morrison. About the Authors Oleg N. Kirillov has been a Research Fellow at theMagneto-Hydrodynamics Division of the Helmholtz-ZentrumDresden-Rossendorf in Germany since 2011. His research interestsinclude non-conservative stability problems of structural mechanicsand physics, perturbation theory of non-self-adjoint boundaryeigenvalue problems, magnetohydrodynamics, friction-inducedoscillations, dissipation-induced instabilities and non-Hermitianproblems of optics and microwave physics. Since 2013 he has servedas an Associate Editor for the journal Frontiers in MathematicalPhysics. Dmitry E. Pelinovsky has been Professor at McMaster University inCanada since 2000. His research profile includes work withnonlinear partial differential equations, discrete dynamicalsystems, spectral theory, integrable systems, and numericalanalysis. He served as the guest editor of the special issue of thejournals Chaos in 2005 and Applicable Analysis in 2010. He is anAssociate Editor of the journal Communications in Nonlinear Scienceand Numerical Simulations. This book is devoted to the problems of spectral analysis,stability and bifurcations arising from the nonlinear partialdifferential equations of modern physics. Leading experts indynamical systems, operator theory, partial differential equations,and solid and fluid mechanics present state-of-the-art approachesto a wide spectrum of new challenging stability problems.Bifurcations and stability of solitary waves, geometrical opticsstability analysis in hydro- and magnetohydrodynamics anddissipation-induced instabilities will be treated with the use ofthe theory of Krein and Pontryagin space, index theory, the theoryof multi-parameter eigenvalue problems and modern asymptotic andperturbative approaches. All chapters contain mechanical andphysical examples and combine both tutorial and advanced sections,making them attractive both to experts in the field andnon-specialists interested in knowing more about modern methods andtrends in stability theory.

An Introduction to the Numerical Analysis of Spectral Methods Numerical Analysis of Spectral MethodsTheory and Applications

Spectral methods are well-suited to solve problems modeled by time-dependent partial differential equations: they are fast, efficient and accurate and widely used by mathematicians and practitioners. This class-tested 2007 introduction, the first on the subject, is ideal for graduate courses, or self-study. The authors describe the basic theory of spectral methods, allowing the reader to understand the techniques through numerous examples as well as more rigorous developments. They provide a detailed treatment of methods based on Fourier expansions and orthogonal polynomials (including discussions of stability, boundary conditions, filtering, and the extension from the linear to the nonlinear situation). Computational solution techniques for integration in time are dealt with by Runge-Kutta type methods. Several chapters are devoted to material not previously covered in book form, including stability theory for polynomial methods, techniques for problems with discontinuous solutions, round-off errors and the formulation of spectral methods on general grids. These will be especially helpful for practitioners.

Spectral Methods And Their Applications Cambridge University Press

A unified discussion of the formulation and analysis of special methods of mixed initial boundary-value problems. The focus is on the development of a new mathematical theory that explains why and how well spectral methods work. Included are interesting extensions of the classical numerical analysis.

Spectral Methods for Non-Standard Eigenvalue Problems John Wiley & Sons

Numerical Analysis of Spectral MethodsTheory and ApplicationsSIAM

Spectral Algorithms CRC Press

Spectral methods refer to the use of eigenvalues, eigenvectors, singular values and singular vectors. They are widely used in Engineering, Applied Mathematics and Statistics. More recently, spectral methods have found numerous applications in Computer Science to "discrete" as well "continuous" problems. Spectral Algorithms describes modern applications of spectral methods, and novel algorithms for estimating spectral parameters. The first part of the book presents applications of spectral methods to problems from a variety of topics including combinatorial optimization, learning and clustering. The second part of the book is motivated by efficiency considerations. A feature of many modern applications is the massive amount of input data. While sophisticated algorithms for matrix computations have been developed over a century, a more recent development is algorithms based on "sampling on the y" from massive matrices. Good estimates of singular values and low rank approximations of the whole matrix can be provably derived from a sample. The main emphasis in the second part of the book is to present these sampling methods with rigorous error bounds. It also presents recent extensions of spectral methods from matrices to tensors and their applications to some combinatorial optimization problems.

A Spectral Method Approach Society for Industrial & Applied

This well-written book explains the theory of spectral methods and their application to the computation of viscous incompressible fluid flow, in clear and elementary terms. With many examples throughout, the work will be useful to those teaching at the graduate level, as well as to researchers working in the area.

A First Course in the Numerical Analysis of Differential Equations SIAM

This book deals with the application of spectral methods to problems of uncertainty propagation and quanti?cation in model-based computations. It speci?cally focuses on computational and algorithmic features of these methods which are most useful in dealing with models based on partial differential equations, with special att- tion to models arising in simulations of ?uid ?ows. Implementations are illustrated through applications to elementary problems, as well as more elaborate examples selected from the authors' interests in incompressible vortex-dominated ?ows and compressible ?ows at low Mach numbers. Spectral stochastic methods are probabilistic in nature, and are consequently rooted in the rich mathematical foundation associated with probability and measure spaces. Despite the authors' fascination with this foundation, the discussion only - ludes to those theoretical aspects needed to set the stage for subsequent applications. The book is authored by practitioners, and is primarily intended for researchers or graduate students in computational mathematics, physics, or ?uid dynamics. The book assumes familiarity with elementary methods for the numerical solution of time-dependent, partial differential equations; prior experience with spectral me- ods is naturally helpful though not essential. Full appreciation of elaborate examples in computational ?uid dynamics (CFD) would require familiarity with key, and in some cases delicate, features of the associated numerical methods. Besides these shortcomings, our aim is to treat algorithmic and computational aspects of spectral stochastic methods with details suf?cient to address and reconstruct all but those highly elaborate examples.

Numerical Methods for Conservation Laws Springer Science & Business Media

Since the publication of "Spectral Methods in Fluid Dynamics" 1988, spectral methods have become firmly established as a mainstream tool for scientific and engineering computation. The authors of that book have incorporated into this new edition the many improvements in the algorithms and the theory of spectral methods that have been made since then. This latest book retains the tight integration between the theoretical and practical aspects of spectral methods, and the chapters are enhanced with material on the Galerkin with numerical integration version of spectral methods. The discussion of direct and iterative solution methods is also greatly expanded.

Spectral Methods in MATLAB Princeton University Press

Along with finite differences and finite elements, spectral methods are one of the three main methodologies for solving partial differential equations on computers. This book provides a detailed presentation of basic spectral algorithms, as well as a systematical presentation of basic convergence theory and error analysis for spectral methods. Readers of this book will be exposed to a unified framework for designing and analyzing spectral algorithms for a variety of problems, including in particular high-order differential equations and problems in unbounded domains. The book contains a large number of figures which are designed to illustrate various concepts stressed in the book. A set of basic matlab codes has been made available online to help the readers to develop their own spectral codes for their specific applications.

Basic and Fundamental Issues Cambridge University Press

In this book, a wide range of problems concerning recent achievements in the field of industrial and applied mathematics are presented. It provides new ideas and research for scientists developing and studying mathematical methods and algorithms, and researchers applying them for solving real-life problems. The importance of the computing infrastructure is unquestionable for the development of modern science. The main focus of the book is the application of mathematics to industry and science. It promotes basic research in mathematics leading to new methods and techniques useful to industry and science. The volume also considers strategy-making integration between scientists of applied mathematics and those working in applied informatics, which has potential for long-lasting integration and co-operation. The integration role is regarded here as a tool for consolidation and reinforcement of the research, education and training, and for the transfer of scientific and management knowledge. This volume operates as a medium for the exchange of information and ideas between mathematicians and other technical and scientific personnel. The book will be essential for the promotion of interdisciplinary collaboration between applied mathematics and science, engineering and technology. The main topics examined in this volume are: numerical methods and algorithms; control systems and applications; partial differential equations and real-life applications; the high performance of scientific computing; linear algebra applications; neurosciences; algorithms in industrial mathematics; equations of mathematical physics; and industrial applications of mechanics.