

Daniele Antonio Di Pietro  
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# Mathematical Aspects of Discontinuous Galerkin Methods



# Mathematical Aspects Of Discontinuous Galerkin Methods Mathématiques Et Applications

**J Elliott**



## **Mathematical Aspects Of Discontinuous Galerkin Methods Mathmatiques Et Applications:**

Mathematical Aspects of Discontinuous Galerkin Methods Daniele Antonio Di Pietro,Alexandre Ern,2011-11-03 This book introduces the basic ideas to build discontinuous Galerkin methods and at the same time incorporates several recent mathematical developments The presentation is to a large extent self contained and is intended for graduate students and researchers in numerical analysis The material covers a wide range of model problems both steady and unsteady elaborating from advection reaction and diffusion problems up to the Navier Stokes equations and Friedrichs systems Both finite element and finite volume viewpoints are exploited to convey the main ideas underlying the design of the approximation The analysis is presented in a rigorous mathematical setting where discrete counterparts of the key properties of the continuous problem are identified The framework encompasses fairly general meshes regarding element shapes and hanging nodes Salient implementation issues are also addressed

Gas Dynamics with Applications in Industry and Life Sciences Mohammad Asadzadeh,Larisa Beilina,Shigeru Takata,2023-10-30 This proceedings volume gathers selected contributions presented at two instances of the JSPS SAC Seminar On Gas Kinetic Dynamics and Life Science held by the Chalmers University of Technology and University of Gothenburg Sweden on March 25 26 2021 virtual and March 17 18 2022 virtual Works in this book provide a concise approach to the theoretical and numerical analysis of kinetic type equations that arise for example in modeling industrial medical and environmental problems Readers will find some of the most recent theoretical results newly developed numerical methods in the field and some open problems Possible application areas encompass fission fusion energy electromagnetics nuclear science and engineering medical service radiation oncology and plants growth conditions to name a few The JSPS SAC seminars are jointly organized by JSPS Japan Society for the Promotion of Science Stockholm Office and the Department of Mathematical Sciences Chalmers University of Technology University of Gothenburg Sweden These seminars foster discussions on the mathematical theory industrial and life science applications and numerical analysis of non linear hyperbolic partial differential equations modeling collision less plasma and charged particles Chapter 4 is available open access under a Creative Commons Attribution 4 0 International License via link [springer.com](https://www.springer.com) Chapter 11 is available open access under a Creative Commons Attribution 4 0 International License via link [springer.com](https://www.springer.com)

**Numerical Mathematics and Advanced Applications - ENUMATH 2013** Assyr Abdule,Simone Deparis,Daniel Kressner,Fabio Nobile,Marco Picasso,2014-11-25 This book gathers a selection of invited and contributed lectures from the European Conference on Numerical Mathematics and Advanced Applications ENUMATH held in Lausanne Switzerland August 26 30 2013 It provides an overview of recent developments in numerical analysis computational mathematics and applications from leading experts in the field New results on finite element methods multiscale methods numerical linear algebra and discretization techniques for fluid mechanics and optics are presented As such the book offers a valuable resource for a wide range of readers looking for a state of the art overview of advanced techniques algorithms and results in numerical

mathematics and scientific computing      **Numerical Mathematics and Advanced Applications ENUMATH 2015** Bülent Karasözen, Murat Manguoğlu, Münevver Tezer-Sezgin, Serdar Göktepe, Ömür Uğur, 2016-11-09 The European Conference on Numerical Mathematics and Advanced Applications ENUMATH held every 2 years provides a forum for discussing recent advances in and aspects of numerical mathematics and scientific and industrial applications The previous ENUMATH meetings took place in Paris 1995 Heidelberg 1997 Jyväskylä 1999 Ischia 2001 Prague 2003 Santiago de Compostela 2005 Graz 2007 Uppsala 2009 Leicester 2011 and Lausanne 2013 This book presents a selection of invited and contributed lectures from the ENUMATH 2015 conference which was organised by the Institute of Applied Mathematics IAM Middle East Technical University Ankara Turkey from September 14 to 18 2015 It offers an overview of central recent developments in numerical analysis computational mathematics and applications in the form of contributions by leading experts in the field

Mathematical and Numerical Modeling of the Cardiovascular System and Applications Daniele Boffi, Luca F.

Pavarino, Gianluigi Rozza, Simone Scacchi, Christian Vergara, 2018-11-03 The book comprises contributions by some of the most respected scientists in the field of mathematical modeling and numerical simulation of the human cardiocirculatory system It covers a wide range of topics from the assimilation of clinical data to the development of mathematical and computational models including with parameters as well as their efficient numerical solution and both in vivo and in vitro validation It also considers applications of relevant clinical interest This book is intended for graduate students and researchers in the field of bioengineering applied mathematics computer computational and data science and medicine wishing to become involved in the highly fascinating task of modeling the cardiovascular system      **Isogeometric Analysis and Applications 2014** Bert Jüttler, Bernd Simeon, 2015-12-21 Isogeometric Analysis is a groundbreaking computational approach that promises the possibility of integrating the finite element method into conventional spline based CAD design tools It thus bridges the gap between numerical analysis and geometry and moreover it allows to tackle new cutting edge applications at the frontiers of research in science and engineering This proceedings volume contains a selection of outstanding research papers presented at the second International Workshop on Isogeometric Analysis and Applications held at Annweiler Germany in April 2014      **Finite Element and Discontinuous Galerkin Methods for Transient Wave**

**Equations** Gary Cohen, Sébastien Pernet, 2016-08-05 This monograph presents numerical methods for solving transient wave equations i e in time domain More precisely it provides an overview of continuous and discontinuous finite element methods for these equations including their implementation in physical models an extensive description of 2D and 3D elements with different shapes such as prisms or pyramids an analysis of the accuracy of the methods and the study of the Maxwell s system and the important problem of its spurious free approximations After recalling the classical models i e acoustics linear elastodynamics and electromagnetism and their variational formulations the authors present a wide variety of finite elements of different shapes useful for the numerical resolution of wave equations Then they focus on the construction of efficient

continuous and discontinuous Galerkin methods and study their accuracy by plane wave techniques and a priori error estimates A chapter is devoted to the Maxwell s system and the important problem of its spurious free approximations Treatment of unbounded domains by Absorbing Boundary Conditions ABC and Perfectly Matched Layers PML is described and analyzed in a separate chapter The two last chapters deal with time approximation including local time stepping and with the study of some complex models i e acoustics in flow gravity waves and vibrating thin plates Throughout emphasis is put on the accuracy and computational efficiency of the methods with attention brought to their practical aspects This monograph also covers in details the theoretical foundations and numerical analysis of these methods As a result this monograph will be of interest to practitioners researchers engineers and graduate students involved in the numerical simulation of waves

**IDIHOM: Industrialization of High-Order Methods - A Top-Down Approach** Norbert Kroll, Charles Hirsch, Francesco Bassi, Craig Johnston, Koen Hillewaert, 2015-01-02 The book describes the main findings of the EU funded project IDIHOM Industrialization of High Order Methods A Top Down Approach The goal of this project was the improvement utilization and demonstration of innovative higher order simulation capabilities for large scale aerodynamic application challenges in the aircraft industry The IDIHOM consortium consisted of 21 organizations including aircraft manufacturers software vendors as well as the major European research establishments and several universities all of them with proven expertise in the field of computational fluid dynamics After a general introduction to the project the book reports on new approaches for curved boundary grid generation high order solution methods and visualization techniques It summarizes the achievements weaknesses and perspectives of the new simulation capabilities developed by the project partners for various industrial applications and includes internal and external aerodynamic as well as multidisciplinary test cases

**Partial Differential Equations: Modeling, Analysis and Numerical Approximation** Hervé Le Dret, Brigitte Lucquin, 2016-02-11 This book is devoted to the study of partial differential equation problems both from the theoretical and numerical points of view After presenting modeling aspects it develops the theoretical analysis of partial differential equation problems for the three main classes of partial differential equations elliptic parabolic and hyperbolic Several numerical approximation methods adapted to each of these examples are analyzed finite difference finite element and finite volumes methods and they are illustrated using numerical simulation results Although parts of the book are accessible to Bachelor students in mathematics or engineering it is primarily aimed at Masters students in applied mathematics or computational engineering The emphasis is on mathematical detail and rigor for the analysis of both continuous and discrete problems

**Finite Elements II** Alexandre Ern, Jean-Luc Guermond, 2021-04-22 This book is the second volume of a three part textbook suitable for graduate coursework professional engineering and academic research It is also appropriate for graduate flipped classes Each volume is divided into short chapters Each chapter can be covered in one teaching unit and includes exercises as well as solutions available from a dedicated website The salient ideas can be addressed during lecture with the rest of the content

assigned as reading material To engage the reader the text combines examples basic ideas rigorous proofs and pointers to the literature to enhance scientific literacy Volume II is divided into 32 chapters plus one appendix The first part of the volume focuses on the approximation of elliptic and mixed PDEs beginning with fundamental results on well posed weak formulations and their approximation by the Galerkin method The material covered includes key results such as the BNB theorem based on inf sup conditions C a s and Strang s lemmas and the duality argument by Aubin and Nitsche Important implementation aspects regarding quadratures linear algebra and assembling are also covered The remainder of Volume II focuses on PDEs where a coercivity property is available It investigates conforming and nonconforming approximation techniques Galerkin boundary penalty Crouzeix Raviart discontinuous Galerkin hybrid high order methods These techniques are applied to elliptic PDEs diffusion elasticity the Helmholtz problem Maxwell s equations eigenvalue problems for elliptic PDEs and PDEs in mixed form Darcy and Stokes flows Finally the appendix addresses fundamental results on the surjectivity bijectivity and coercivity of linear operators in Banach spaces

**The Virtual Element Method and its Applications** Paola F. Antonietti, Lourenço Beirão da Veiga, Gianmarco Manzini, 2022-10-08 The purpose of this book is to present the current state of the art of the Virtual Element Method VEM by collecting contributions from many of the most active researchers in this field and covering a broad range of topics from the mathematical foundation to real life computational applications The book is naturally divided into three parts The first part of the book presents recent advances in theoretical and computational aspects of VEMs discussing the generality of the meshes suitable to the VEM the implementation of the VEM for linear and nonlinear PDEs and the construction of discrete hessian complexes The second part of the volume discusses Virtual Element discretization of paradigmatic linear and non linear partial differential problems from computational mechanics fluid dynamics and wave propagation phenomena Finally the third part contains challenging applications such as the modeling of materials with fractures magneto hydrodynamics phenomena and contact solid mechanics The book is intended for graduate students and researchers in mathematics and engineering fields interested in learning novel numerical techniques for the solution of partial differential equations It may as well serve as useful reference material for numerical analysts practitioners of the field

**The Gradient Discretisation Method** Jérôme Droniou, Robert Eymard, Thierry Gallouët, Cindy Guichard, Raphaële Herbin, 2018-07-31 This monograph presents the Gradient Discretisation Method GDM which is a unified convergence analysis framework for numerical methods for elliptic and parabolic partial differential equations The results obtained by the GDM cover both stationary and transient models error estimates are provided for linear and some non linear equations and convergence is established for a wide range of fully non linear models e g Leray Lions equations and degenerate parabolic equations such as the Stefan or Richards models The GDM applies to a diverse range of methods both classical conforming non conforming mixed finite elements discontinuous Galerkin and modern mimetic finite differences hybrid and mixed finite volume MPFA O finite volume some of which can be built on very general meshes span style ms

mincho mso bidi font family the core properties and analytical tools required to work within gdm are stressed it is shown that scheme convergence can often be established by verifying a small number of properties scope some featured techniques results such as time space compactness theorems discrete aubin simon discontinuous ascoli arzela goes beyond gdm making them potentially applicable numerical schemes not yet known fit into this framework span style font family ms mincho mso bidi font family this monograph is intended for graduate students researchers and experts in the field of numerical analysis partial differential equations ppiiiiibr i i i i p

**Numerical Methods and Applications** Ivan Georgiev, Maria Datcheva, Krassimir Georgiev, Geno Nikolov, 2023-05-15 This book constitutes the thoroughly refereed post conference proceedings of the 10th International Conference on Numerical Methods and Applications NMA 2022 held in Borovets Bulgaria in August 2022 The 30 revised regular papers presented were carefully reviewed and selected from 38 submissions for inclusion in this book The papers are organized in the following topical sections numerical search and optimization problem driven numerical method motivation and application numerical methods for fractional diffusion problems orthogonal polynomials and numerical quadratures and Monte Carlo and Quasi Monte Carlo methods

**Parallel Processing and Applied Mathematics** Roman Wyrzykowski, Ewa Deelman, Jack Dongarra, Konrad Karczewski, 2020-03-19 The two volume set LNCS 12043 and 12044 constitutes revised selected papers from the 13th International Conference on Parallel Processing and Applied Mathematics PPAM 2019 held in Bialystok Poland in September 2019 The 91 regular papers presented in these volumes were selected from 161 submissions For regular tracks of the conference 41 papers were selected from 89 submissions The papers were organized in topical sections named as follows Part I numerical algorithms and parallel scientific computing emerging HPC architectures performance analysis and scheduling in HPC systems environments and frameworks for parallel distributed cloud computing applications of parallel computing parallel non numerical algorithms soft computing with applications special session on GPU computing special session on parallel matrix factorizations Part II workshop on language based parallel programming models WLPP 2019 workshop on models algorithms and methodologies for hybrid parallelism in new HPC systems workshop on power and energy aspects of computations PEAC 2019 special session on tools for energy efficient computing workshop on scheduling for parallel computing SPC 2019 workshop on applied high performance numerical algorithms for PDEs minisymposium on HPC applications in physical sciences minisymposium on high performance computing interval methods workshop on complex collective systems Chapters Parallel adaptive cross approximation for the multi trace formulation of scattering problems and A High Order Discontinuous Galerkin Solver with Dynamic Adaptive Mesh Refinement to Simulate Cloud Formation Processes of LNCS 12043 are available open access under a Creative Commons Attribution 4.0 International License via link [springer.com](https://www.springer.com)

**The Concept of Stability in Numerical Mathematics** Wolfgang Hackbusch, 2014-02-06 In this book the author compares the meaning of stability in different subfields of numerical mathematics Concept of Stability in numerical mathematics opens by

examining the stability of finite algorithms A more precise definition of stability holds for quadrature and interpolation methods which the following chapters focus on The discussion then progresses to the numerical treatment of ordinary differential equations ODEs While one step methods for ODEs are always stable this is not the case for hyperbolic or parabolic differential equations which are investigated next The final chapters discuss stability for discretisations of elliptic differential equations and integral equations In comparison among the subfields we discuss the practical importance of stability and the possible conflict between higher consistency order and stability

*Anisotropic hp-Mesh Adaptation Methods* Vít Dolejší, Georg May, 2022-06-06 Mesh adaptation methods can have a profound impact on the numerical solution of partial differential equations If devised and implemented properly adaptation significantly reduces the size of the algebraic systems resulting from the discretization while ensuring that applicable error tolerances are met In this monograph drawing from many years of experience the authors give a comprehensive presentation of metric based anisotropic hp mesh adaptation methods A large part of this monograph is devoted to the derivation of computable interpolation error estimates on simplicial meshes which take into account the geometry of mesh elements as well as the anisotropic features of the interpolated function These estimates are then used for the optimization of corresponding finite element spaces in a variety of settings Both steady and time dependent problems are treated as well as goal oriented adaptation Practical aspects of implementation are also explored including several algorithms Many numerical experiments using the discontinuous Galerkin method are presented to illustrate the performance of the adaptive techniques This monograph is intended for scientists and researchers including doctoral and master level students Portions of the text can also be used as study material for advanced university lectures concerning a posteriori error analysis and mesh adaptation

[Error Control, Adaptive Discretizations, and Applications, Part 2](#), 2024-10-31 Error Control Adaptive Discretizations and Applications Volume 59 Part Two highlights new advances in the field with this new volume presenting interesting chapters written by an international board of authors Chapters in this release cover hp adaptive Discontinuous Galerkin strategies driven by a posteriori error estimation with application to aeronautical flow problems An anisotropic mesh adaptation method based on gradient recovery and optimal shape elements and Model reduction techniques for parametrized nonlinear partial differential equations Covers multi scale modeling Includes updates on data driven modeling Presents the latest information on large deformations of multi scale materials

*Transport Processes at Fluidic Interfaces* Dieter Bothe, Arnold Reusken, 2017-07-13 There are several physico chemical processes that determine the behavior of multiphase fluid systems e g the fluid dynamics in the different phases and the dynamics of the interface s mass transport between the fluids adsorption effects at the interface and transport of surfactants on the interface and result in heterogeneous interface properties In general these processes are strongly coupled and local properties of the interface play a crucial role A thorough understanding of the behavior of such complex flow problems must be based on physically sound mathematical models which especially account for the local processes at the



interface This book presents recent findings on the rigorous derivation and mathematical analysis of such models and on the development of numerical methods for direct numerical simulations Validation results are based on specifically designed experiments using high resolution experimental techniques A special feature of this book is its focus on an interdisciplinary research approach combining Applied Analysis Numerical Mathematics Interface Physics and Chemistry as well as relevant research areas in the Engineering Sciences The contributions originated from the joint interdisciplinary research projects in the DFG Priority Programme SPP 1506 Transport Processes at Fluidic Interfaces

Geometrically Unfitted Finite Element Methods and Applications Stéphane P. A. Bordas, Erik Burman, Mats G. Larson, Maxim A. Olshanskii, 2018-03-13 This book provides a snapshot of the state of the art of the rapidly evolving field of integration of geometric data in finite element computations The contributions to this volume based on research presented at the UCL workshop on the topic in January 2016 include three review papers on core topics such as fictitious domain methods for elasticity trace finite element methods for partial differential equations defined on surfaces and Nitsche's method for contact problems Five chapters present original research articles on related theoretical topics including Lagrange multiplier methods interface problems bulk surface coupling and approximation of partial differential equations on moving domains Finally two chapters discuss advanced applications such as crack propagation or flow in fractured poroelastic media This is the first volume that provides a comprehensive overview of the field of unfitted finite element methods including recent techniques such as cutFEM traceFEM ghost penalty and augmented Lagrangian techniques It is aimed at researchers in applied mathematics scientific computing or computational engineering

**Godunov Methods** E.F. Toro, 2012-12-06 This edited review book on Godunov methods contains 97 articles all of which were presented at the international conference on Godunov Methods Theory and Applications held at Oxford in October 1999 to commemorate the 70th birthday of the Russian mathematician Sergei K Godunov The meeting enjoyed the participation of 140 scientists from 20 countries one of the participants commented everyone is here meaning that virtually everybody who had made a significant contribution to the general area of numerical methods for hyperbolic conservation laws along the lines first proposed by Godunov in the fifties was present at the meeting Sadly there were important absentees who due to personal circumstance could not attend this very exciting gathering The central theme of the meeting and of this book was numerical methods for hyperbolic conservation laws following Godunov's key ideas contained in his celebrated paper of 1959 But Godunov's contributions to science are not restricted to Godunov's method

This book delves into Mathematical Aspects Of Discontinuous Galerkin Methods Mathmatiques Et Applications. Mathematical Aspects Of Discontinuous Galerkin Methods Mathmatiques Et Applications is a vital topic that must be grasped by everyone, from students and scholars to the general public. The book will furnish comprehensive and in-depth insights into Mathematical Aspects Of Discontinuous Galerkin Methods Mathmatiques Et Applications, encompassing both the fundamentals and more intricate discussions.

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