Editors:

Timothy J. Barth

Michael Griebel

David E. Keyes

Risto M. Nieminen

Dirk Roose

Tamar Schlick

More information about this series at <http://www.springer.com/series/3527>

Petr Knobloch

Editor

Boundary and Interior Layers, Computational and Asymptotic Methods – BAIL 2014

Springer

Editor

Petr Knobloch
Faculty of Mathematics and Physics
Charles University in Prague
Praha, Czech Republic

ISSN 1439-7358 ISSN 2197-7100 (electronic)
Lecture Notes in Computational Science and Engineering
ISBN 978-3-319-25725-9 ISBN 978-3-319-25727-3 (eBook)
DOI 10.1007/978-3-319-25727-3

Library of Congress Control Number: 2015957960

Mathematics Subject Classification (2010): 34-XX, 35-XX, 65Lxx, 65Mxx, 65Nxx, 76Dxx.

Springer Cham Heidelberg New York Dordrecht London
© Springer International Publishing Switzerland 2015

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, express or implied, with respect to the material contained herein or for any errors or omissions that may have been made.

Printed on acid-free paper

Springer International Publishing AG Switzerland is part of Springer Science+Business Media
(www.springer.com)

Preface

These Proceedings contain contributions reflecting a selection of the lectures presented at the conference *BAIL 2014: Boundary and Interior Layers – Computational and Asymptotic Methods*, which was held from 15 to 19 September 2014 at Charles University in Prague, Czech Republic. Apart from two hiatuses, the BAIL conferences have been held every 2 years and BAIL 2014 was already the 14th conference in this series. The first three BAIL conferences were organized by Professor John Miller in Dublin (1980, 1982, 1984). The next ten were held in Novosibirsk (1986), Shanghai (1988), Colorado (1992), Beijing (1994), Perth (2002), Toulouse (2004), Göttingen (2006), Limerick (2008), Zaragoza (2010), and Pohang (2012). BAIL 2016 is planned for Beijing.

The conference BAIL 2014 attracted 54 participants from 15 countries in three continents. They presented 50 lectures, five of which were invited. Almost half of the speakers present the contents of their lectures in these Proceedings. The conference included two mini-symposia devoted to stabilized methods in aerodynamics modeling and tailored finite point method for problems with non-smooth solution. As usual, both mathematicians (pure and applied) and engineers participated in this BAIL conference, which led to a very fruitful exchange of ideas. A positive aspect was also the participation of several PhD students, showing that the topics of the conference remain attractive also for young scientists. The lectures at the conference comprised both rigorous mathematical results on problems with layers and their numerical solution and complicated computational techniques for advanced applications.

The contributions in these Proceedings are devoted to theoretical and/or numerical analysis of problems involving boundary and interior layers and of methods for solving these problems numerically. Almost half of the contributions study fluid flow problems, whereas the remaining contributions contain results on convection–diffusion, convection–diffusion–reaction, and reaction–diffusion equations. Both steady and transient problems are considered. Most of the numerical schemes presented in these Proceedings are based on the finite element method, closely followed by the finite difference method. Nevertheless, in three cases, also solvers based on the finite volume method are applied. The topics covered by the contributions

include theoretical analyses of various (stabilized) numerical schemes, typically represented by stability results and error estimates; analyses for various adapted meshes, in particular, uniform error estimates on Shishkin meshes; a posteriori error estimation; various approaches to turbulence modelling; studies of the influence of finite precision arithmetic; computational techniques for advanced applications; asymptotic theory of boundary layers; and investigations of layer phenomena in convection–diffusion problems with fractional derivatives. Almost all contributions contain numerical results illustrating the respective theoretical considerations. In view of the wide variety of topics treated in the contributions, the Proceedings provide a very good overview of current research into the theory and numerical solution of problems involving boundary and interior layers.

All contributions in the Proceedings were subject to a standard refereeing process. I would like to thank the authors of the contributions for their cooperation and the unnamed referees for their valuable suggestions that contributed to the high quality of this volume.

I also wish to thank the organizers of the mini-symposia at BAIL 2014, all the attendees for their active participation in the conference, and my colleagues Hana Orosová, Jiří Felcman, Jan Lamač, and Petr Lukáš for their help with the organization of the conference.

Praha, Czech Republic
August 2015

Petr Knobloch

Contents

A Note on the Stabilised Q_1-P_0 Method on Quadrilaterals with High Aspect Ratios	1
Gabriel R. Barrenechea and Andreas Wachtel	
A Posteriori Error Estimation of a Stabilized Mixed Finite Element Method for Darcy Flow	13
Tomás Patricio Barrios, José Manuel Cascón, and María González	
A Local Projection Stabilized Lagrange-Galerkin Method for Convection-Diffusion Equations	25
Rodolfo Bermejo, Rafael Cantón, and Laura Saavedra	
Outflow Conditions for the Navier-Stokes Equations with Skew-Symmetric Formulation of the Convective Term	35
Malte Braack	
Finite Element Approximation of an Unsteady Projection-Based VMS Turbulence Model with Wall Laws	47
Tomás Chacón Rebollo, Macarena Gómez Mármol, and Samuele Rubino	
Spatial Semidiscretizations and Time Integration of 2D Parabolic Singularly Perturbed Problems	75
Carmelo Clavero and Juan Carlos Jorge	
Boundary Layers in a Riemann-Liouville Fractional Derivative Two-Point Boundary Value Problem	87
José Luis Gracia and Martin Stynes	
On the Application of Algebraic Flux Correction Schemes to Problems with Non-vanishing Right-Hand Side	99
Petr Knobloch	

Investigation of Numerical Wall Functions Based on the 1D Boundary-Layer Equations for Flows with Significant Pressure Gradient	111
Tobias Knopp, Fabian Spallek, Octavian Frederich, and Gerd Rapin	
Modified SUPG Method on Oriented Meshes	121
Jan Lamač	
On Numerical Simulation of Transition to Turbulence in Turbine Cascade	135
Petr Louda, Karel Kozel, and Jaromír Příhoda	
Understanding the Limits of Inf-Sup Stable Galerkin-FEM for Incompressible Flows	147
Gert Lube, Daniel Arndt, and Helene Dallmann	
A Posteriori Optimization of Parameters in the SUPG Method for Higher Degree FE Spaces	171
Petr Lukáš	
A Parameter-Uniform First Order Convergent Numerical Method for a System of Singularly Perturbed Second Order Delay Differential Equations	183
Manikandan Mariappan, John J.H. Miller, and Valarmathi Sigamani	
Numerical Simulation of Air Jet Attachment to Convex Walls and Application to UAV	197
Nikola Mirkov and Boško Rašuo	
Cholesky Factorisation of Linear Systems Coming from Finite Difference Approximations of Singularly Perturbed Problems	209
Thái Anh Nhan and Niall Madden	
Numerical Experiments with a Linear Convection–Diffusion Problem Containing a Time-Varying Interior Layer	221
Eugene O’Riordan and Jason Quinn	
Second Order Uniformly Convergent Numerical Method for a Coupled System of Singularly Perturbed Reaction-Diffusion Problems with Discontinuous Source Term	233
S. Chandra Sekhara Rao and Sheetal Chawla	
A Multiscale Sparse Grid Technique for a Two-Dimensional Convection-Diffusion Problem with Exponential Layers	245
Stephen Russell and Niall Madden	
On the Delay and Inviscid Nature of Turbulent Break-Away Separation in the High-<i>Re</i> Limit	257
Bernhard Scheichl	

Use of Standard Difference Scheme on Uniform Grids for Solving Singularly Perturbed Problems Under Computer Perturbations	269
Grigorii Shishkin	
Difference Schemes of High Accuracy Order on Uniform Grids for a Singularly Perturbed Parabolic Reaction-Diffusion Equation	281
Lidia Shishkina	
Blow-Up of Solutions and Interior Layers in a Caputo Two-Point Boundary Value Problem.....	293
Martin Stynes and José Luis Gracia	
On Finite Element Approximation of Fluid-Structure Interactions with Consideration of Transition Model.....	303
Petr Sváček	