Numerical Solution of Singularly Perturbed Problems via both Galerkin and Subdomain Galerkin methods

Ozlem Ersoy Hepson[1] and Idris Dag[2]

Department of Mathematics-Computer[1]

Computer Engineering Department[2]

Eskişehir Osmangazi Üniversity, Eskişehir, Turkey,

Abstract

In this paper, numerical solutions of singularly perturbed boundary value problems are given by using variants of finite element method. Both Galerkin and subdomain Galerkin method based on quadratic B-spline functions are applied over the geometrically graded. Results of some text problems are compated with analytical solutions of the singularly perturbed problem

Keywords: Subdomain Galerkin, graded mesh, spline, singularly perturbed.

1   Introduction

This paper contains numerical solutions of one dimensional singularly perturbation problems

$$- \varepsilon u'' + p(x)u' + q(x)u = f(x), \quad x \in [0, 1] \tag{1}$$

with boundary conditions

$$u(0) = \lambda \text{ and } u(1) = \beta, \ \lambda, \ \beta \in \mathbb{R} \tag{2}$$

where ε is a small positive parameter, $p(x)$, $q(x)$, $f(x)$ are sufficiently smooth functions with $p(x) \geq p^* > 0$, $q(x) \geq q^* > 0$. These problems depend on ε in such a way that the solution varies rapidly in some parts and varies slowly

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Numerical Methods for Singularly Perturbed Differential Equations Hans-Görg Roos,1996 This book collects explains and analyses basic methods and recent results for the successful numerical solution of singularly perturbed differential equations Such equations model many physical phenomena and their solutions are characterized by the presence of layers The book is a wide ranging introduction to the exciting current literature in this area It concentrates on linear convection diffusion equations and related nonlinear flow problems encompassing both ordinary and partial differential equations While many numerical methods are considered particular attention is paid to those with realistic error estimates The book provides a solid and thorough foundation for the numerical analysis and solution of singular perturbation problems **Difference Methods for Singular Perturbation Problems** Grigory I. Shishkin,Lidia P. Shishkina,2008-09-22 Difference Methods for Singular Perturbation Problems focuses on the development of robust difference schemes for wide classes of boundary value problems It justifies the uniform convergence of these schemes and surveys the latest approaches important for further progress in numerical methods The first part of the book e Fitted Numerical Methods for Singular Perturbation Problems John J. H. Miller,Eugene O'Riordan,G. I. Shishkin,2012 Since the first edition of this book the literature on fitted mesh methods for singularly perturbed problems has expanded significantly Over the intervening years fitted meshes have been shown to be effective for an extensive set of singularly perturbed partial differential equations In the revised version of this book the reader will find an introduction to the basic theory associated with fitted numerical methods for singularly perturbed differential equations Fitted mesh methods focus on the appropriate distribution of the mesh points for singularly perturbed problems The global errors in the numerical approximations are measured in the pointwise maximum norm The fitted mesh algorithm is particularly simple to implement in practice but the theory of why these numerical methods work is far from simple This book can be used as an introductory text to the theory underpinning fitted mesh methods

Numerical Methods for Singularly Perturbed Differential Equations Hans-G. Roos,Martin Stynes,Lutz Tobiska,1996-03-14 The analysis of singular perturbed differential equations began early in this century when approximate solutions were constructed from asymptotic ex pansions Preliminary attempts appear in the nineteenth century vD94 This technique has flourished since the mid 1960s Its principal ideas and methods are described in several textbooks Nevertheless asymptotic ex pansions may be impossible to construct or may fail to simplify the given problem then numerical approximations are often the only option The systematic study of numerical methods for singular perturbation problems started somewhat later in the 1970s While the research frontier has been steadily pushed back the exposition of new developments in the analysis of numerical methods has been neglected Perhaps the only example of a textbook that concentrates on this analysis is DMS80 which collects various results for ordinary differential equations but many methods and techniques that are relevant today especially for partial differential equa tions were developed after 1980 Thus

contemporary researchers must comb the literature to acquaint themselves with earlier work Our purposes in writing this introductory book are twofold First we aim to present a structured account of recent ideas in the numerical analysis of singularly perturbed differential equations Second this important area has many open problems and we hope that our book will stimulate further investigations Our choice of topics is inevitably personal and reflects our own main interests

Singular-Perturbation Theory Donald R. Smith,1985-08-30 Introduction to singular perturbation problems Since the nature of the nonuniformity can vary from case to case the author considers and solves a variety of problems mostly for ordinary differential equations   Robust Numerical Methods for Singularly Perturbed Differential Equations Hans-Görg Roos,Martin Stynes,Lutz Tobiska,2008-09-17 This new edition incorporates new developments in numerical methods for singularly perturbed differential equations focusing on linear convection diffusion equations and on nonlinear flow problems that appear in computational fluid dynamics   **Layer Resolving Grids and Transformations for Singular Perturbation Problems** Vladimir D. Liseikin,2018-11-05 No detailed description available for Layer Resolving Grids and Transformations for Singular Perturbation Problems   *On the Numerical Solution of Singularly Perturbed Linear Two-Point Boundary-Value Problems* B. S. Ng,W. H. Reid,INDIANA UNIV-PURDUE UNIV AT INDIANAPOLIS.,1985 This article presents an initial value technique based on the use of certain compound matrices for the numerical solution of linear two point boundary value problems involving unstable ordinary differential equations of the singular perturbation type The authors demonstrate the effectiveness of the method via certain examples which exhibit internal as well as end point boundary layers   **The Asymtotic Behavior and Numerical Solution of Singular Perturbation Problems with Turning Points** Fred W. Dorr,1969   **Analytical and Numerical Methods for Convection-dominated and Singularly Perturbed Problems** Lubin Vulkov,John James Henry Miller,2000 This volume is the Proceedings of the Workshop on Analytical and Computational Methods for Convection Dominated and Singularly Perturbed Problems which took place in Lozenetz Bulgaria 27 31 August 1998 The workshop attracted about 50 participants from 12 countries The volume includes 13 invited lectures and 19 contributed papers presented at the workshop and thus gives an overview of the latest developments in both the theory and applications of advanced numerical methods to problems having boundary and interior layers There was an emphasis on experiences from the numerical analysis of such problems and on theoretical developments The aim of the workshop was to provide an opportunity for scientists from the East and the West who develop robust methods for singularly perturbed and related problems and also who apply these methods to real life problems to discuss recent achievements in this area and to exchange ideas with a view of possible research co operation   Numerical Solution of Stiff and Singularly Perturbed Problems A. M. Nagy,2013 In recent years much attention has been given to the numerical solution of ODEs Of particular interest has been the solution of singularly perturbed and stiff problems These types of problems arise in various fields of science and engineering such as fluid mechanics physics chemistry mechanics chemical reactor theory convection diffusion

processes optimal control and other branches of applied mathematics Singular perturbation problems depend on the presence of a small positive parameter which provides a multi scale character to the solution That is the solution varies very rapidly in some parts of the region of integration layers and varies slowly in other parts Stiffness is a property of the differential problem that makes slow and expensive the computation of the numerical solution using classical explicit methods In this work we present some numerical methods for solving IVPs and BVBs Moreover we give numerical solutions of Volterra integral and integro differential equations This book is high recommended to both postgraduate students and researchers in a wide variety of applications *The Robust and Efficient Numerical Solution of Singularly Perturbed Boundary Value Problems Using Grid Adaptivity* Mark George Beckett,1998 *Single Perturbation Problems in Chemical Physics* John J. H. Miller,2009-09-09 The Matching Method for Asymptotic Solutions in Chemical PhysicsProblems by A M Il in L A Kalyakin and S I Maslennikov Singularly Perturbed Problems with Boundary and Interior Layers Theory and Application by V F Butuzov and A B Vasilieva Numerical Methods for Singularly Perturbed Boundary Value ProblemsModeling Diffusion Processes by V L Kolmogorov and G I Shishkin An important addition to the Advances in Chemical Physics series this volume makes available for the first time in English the workof leading Russian researchers in singular perturbation theory andits application Since boundary layers were first introduced byPrandtl early in this century rapid advances have been made in theanalytic and numerical investigation of these phenomena andnowhere have these advances been more notable than in the Russianschool of singular perturbation theory The three chapters in thisvolume treat various aspects of singular perturbations and theirnumerical solution and represent some of the best work done inthis area The first chapter The Matching Method for Asymptotic Solutionsin Chemical Physics Problems is concerned with the analysis ofsome singular perturbation problems that arise in chemicalkinetics In this chapter the matching method is applied to findasymptotic solutions to some dynamical systems of ordinarydifferential equations whose solutions have multiscale timedependence The second chapter Singularly Perturbed Problems with Boundaryand Interior Layers Theory and Application offers acomprehensive overview of the theory and application of asymptoticapproximations for many different kinds of problems in chemicalphysics governed by either ordinary or partial differentialequations with boundary and interior layers The third chapter Numerical Methods for Singularly PerturbedBoundary Value Problems Modeling Diffusion Processes discussesthe numerical difficulties that arise in solving the problemsdescribed in the first two chapters and proposes rigorous criteriafor determining whether or not a numerical method is satisfactoryfor such problems Methods satisfying these criteria are thenconstructed and applied to obtain numerical solutions to a range ofsample problems Timely authoritative and invaluable to researchers in all areasof chemical physics Singular Perturbation Problems in ChemicalPhysics is an essential resource Numerical Analysis of Singular Perturbation Problems P. W. Hemker,John James Henry Miller,1979 14 lectures by the invited speakers and 14 shorter contributions from the other speakers pref

<u>Mathematical Reviews</u> ,2005   **Multigrid Applied to Singular Perturbation Problems** David Kamowitz,1987 The solution of the singular perturbation problem epsilon u 2 primers b x u one primer f 0x   *Invited Lectures Delivered at the Seventh International Colloquium on Differential Equations, August 18-23, 1996, Plovdiv, Bulgaria* ,1996   **Computational Mathematics and Mathematical Physics** ,1991   **The Engineering Index Annual** ,1992 Since its creation in 1884 Engineering Index has covered virtually every major engineering innovation from around the world It serves as the historical record of virtually every major engineering innovation of the 20th century Recent content is a vital resource for current awareness new production information technological forecasting and competitive intelligence The world s most comprehensive interdisciplinary engineering database Engineering Index contains over 10 7 million records Each year over 500 000 new abstracts are added from over 5 000 scholarly journals trade magazines and conference proceedings Coverage spans over 175 engineering disciplines from over 80 countries Updated weekly   *Russian Journal of Numerical Analysis and Mathematical Modelling* ,1998

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