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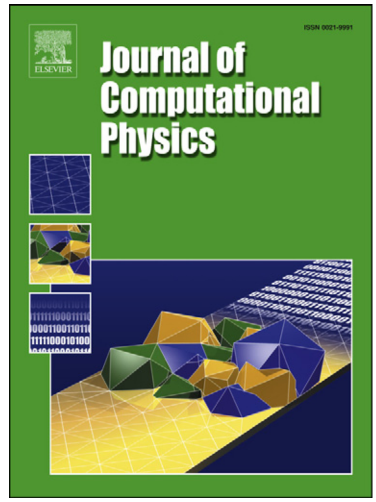

Finite difference approximations of multidimensional unsteady convection–diffusion–reaction equations

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Finite difference approximations of multidimensional unsteady convection-diffusion-reaction equations

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Abstract

In this paper, the numerical approximation of unsteady convection-diffusion-reaction equations with finite difference method on a special grid is studied in the convection or reaction-dominated regime. We extend the method [19] which was designed for multidimensional steady convection-diffusion-reaction equations to unsteady problems. We investigate two possible different ways of combining the discretization in time and in space (where the sequence of the discretizations is interchanged). Discretization in time is performed by using Crank-Nicolson and Backward-Euler finite difference schemes, while for the space discretization we consider the method [19]. Numerical tests are presented to show good performance of the method.

Keywords: Finite difference method; Finite element method; unsteady convection-diffusion-reaction

1. Introduction

Numerical solution of unsteady convection-diffusion-reaction (CDR) equations is an active research area. It is well known that when convection or reaction dominates standard Galerkin finite element method and central finite difference scheme produce undesired oscillations that pollute whole domain and stabilized methods have to be utilized. Within finite difference approaches, upwinding is one of the earliest and simple one to deal with convection-dominated problems. In the last few decades, essentially non-oscillatory (ENO) [17] and weighted ENO (WENO) [18] schemes have been developed in the context of hyperbolic partial differential equations. These schemes use a wider stencil than the simple upwinding. A comprehensive comparison of these methods was studied in [16]. Within finite element methods, one of the early attempts is streamline-upwind Petrov-Galerkin (SUPG) method which is first proposed in [6]. It is widely employed for many different applications, however, possible drawbacks of the method are its complexity and the presence of a stabilizing parameter that needs to be properly tuned for each problem. A more recent approach is the residual-free bubble method (RFB) which is based on enriching the finite element space. It is

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