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Piotr Matus, Dmitriy Poliakov, Le Minh Hieu

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On the Consistent Two-side Estimates for the Solutions of Quasilinear Convection-Diffusion Equations and Their Approximations on Non-uniform Grids

Piotr Matus*

Institute of Mathematics and Computer Science, The John Paul II Catholic University of Lublin, Al. Raclawickie 14, 20-950 Lublin, Poland,
and Institute of Mathematics, NAS of Belarus, 11 Surganov Str., 20072 Minsk, Belarus

Dmitriy Poliakov

Institute of Mathematics, NAS of Belarus, 11 Surganov Str., 20072 Minsk, Belarus

Le Minh Hieu

Belarusian State University, 4 Nezavisimosti avenue, 220030 Minsk, Belarus,
and University of Economics, The University of Danang, 71 Ngu Hanh Son Str., 590000 Danang, Vietnam

Abstract

A new second-order in space linearized difference scheme on non-uniform grid that approximates the Dirichlet problem for multidimensional quasilinear convection-diffusion equation with unbounded nonlinearity is constructed. Proposed algorithm is a novel nonlinear generalization of difference schemes for linear problems developed earlier by the authors. Nontrivial two-side pointwise estimates of the solution of the scheme fully consistent with the corresponding estimates for the differential problem are established. Such estimates permit to prove the nonnegativity of the exact solution, important in physical problems, and also to find sufficient conditions on the input data when the nonlinear problem is parabolic. As a result a priori estimates of the approximate solution in the grid norm C that depend on the initial and boundary conditions and on the right-hand side only are proved.

Keywords: Maximum principle, monotone difference scheme, quasilinear convection-diffusion equation, second order of approximation, non-uniform grid

1. Introduction

The maximum principle allows not only to prove uniqueness and continuous dependence on the input data of the solution of the initial-boundary problems for parabolic and elliptic equations, but, in contrast to the method of energy inequalities, to obtain a priori (upper) estimates of the solution in the uniform norm for such problems in arbitrary dimension with nonselfadjoint elliptic operator [1, p. 500]. In the theory of difference schemes, the maximum principle is also used for studying the stability of a difference solution with respect to input data and its convergence to an exact solution of the problem in a uniform norm. Finite-difference methods that satisfy grid maximum principle are usually called monotone [2, p. 228]. Different classes of monotone difference schemes are developed and investigated for multidimensional linear convection-diffusion equations (see, e.g., the monograph [3, p. 35]). Monotone schemes play an important

*Corresponding author
Email addresses: matus@im.bas-net.by (Piotr Matus), mitia87@gmail.com (Dmitriy Poliakov), lmhieuktdn@gmail.com (Le Minh Hieu)

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