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Numerical methods of the decision of the differential equations and the integrated equations of mathematical physics and mechanics

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Abstract

I) The investigations are devoted to development and investigation of the FEM schemes for singularly perturbed convection-diffusion problems. The finite elements scheme with exponential piecewise approximation is constructed for solving one-dimensional convection-diffusion problems. Sufficient condition of stability, a-priori estimate of convergence and optimal base of the exponential functions for the scheme are established. The exponential one-step recurrent integration scheme for parabolic initial boundary value problems is constructed. We also proposed method transformation of the variational convection-diffusion problem to equivalent minimization problem of quadratic functional by Petrov-Galerkin method with a special choice of space test functions. The algorithm generates meshes close to equilateral triangles. A posteriori errors estimators for finite element method approximations of one- and two-dimensional singularly perturbed convection-diffusion problem are constructed. The estimators are computed by solving a local residual problem using exponential approximation. Based on the estimators and stable exponential approximation h-adaptive FEM scheme is designed. The efficiency and reliability of proposed methods are illustrated by numerical experiments with model problems.

II) The research unit is boundary value problem in potential theory and Fredholm integral equation of the first kind with weak singularity in the kernel. Mathematical models of appropriate physical phenomenons are also the object if own investigation.

The main purpose is the construction and justification of schemes which are the basis of computing experiments in physical and mechanical problems. The latter are described by means of singularly perturbed value and initial boundary value direct and inverse problems for system of partial differential equations. The construction and justification of numerical approaches for mathematical physics and inverse problems solution obtained by integral and nonlinear functional equation method have been also investigated.

To solve the above problems we used some methods of mathematical analysis, the theory of numerical method, the theory of differential equation, the finite elements method and the integral equation one We constructed own researches by use integral equations of various kings and dimensions, Laguerre transformation, Green functions, the decomposition of complex irregular domains. The problems of approximate schemes construction, corresponding operators and spaces approximation, stability and convergence have been considered. The numerical schemes to solve inverse problems of cracks, inclusions and boundary value restitution in partially-unbounded domains for Laplace equation, heat equation and Navie system have been constructed. The convergence of iterative process with super quadratic degree of convergence for certain class of nonlinear equations was proved.