Brief information about the project

Name of the project	AP19579325 «Development and research of modern numerical methods for solving inverse and ill-posed problems for the acoustics equation» (0123PK00172)
Relevance	This project is dedicated to the development of new results in the field of modern numerical solutions of inverse and ill-posed problems for the acoustics equation. There is an obvious need for accurate methods of modeling wave fields in the time domain in complex geometric forms. Solving this type of problem with acoustic waves is important from a practical point of view, since real experiments with acoustic waves are cheaper, easier and safer. In this project, new combined numerical methods for their solution will be constructed.
Purpose	The aim of the project is to research and develop modern numerical methods for solving direct and inverse problems for the acoustics equation, to develop optimization and regularization methods for solving inverse and incorrect problems for the acoustics equation, which are widely used in seismics, geophysics and medicine.
Objectives	– Investigation of the correctness of inverse problems for the acoustics equation in applications of geophysics, tomography and seismics. In the study of direct and inverse problems for the acoustics equation, questions on the uniqueness and stability of the solution will be studied, to assess the resolution, to assess the sensitivity of physical measurements with respect to variations in the basic parameters of physical models. – Formulation and study of mathematical models of geophysics described by partial differential equations of hyperbolic type. New formulations of the problem of the continuation of potential fields from the Earth's surface into the depths, which is found in gravity and magnetic exploration, are considered. – Investigation of the degree of incorrectness of inverse problems and obtaining estimates of the conditional stability of solving inverse problems for the studied mathematical models. The main attention will be paid to two-dimensional inverse problems of acoustics in the case when the sources of wave processes and receivers (measuring additional information about solving direct problems) are located on the same plane. The project plans to develop methods for regularization of the problem of continuation of the solution of the wave equation with data on the time of a similar surface with data on a part of the boundary. – The development and analysis of modern numerical methods for solving inverse and ill-posed problems for the wave type of the equation has wide application in geophysics, medicine and seismics. Numerical solution of direct and inverse problems for two-dimensional

	hyperbolic and elliptic equations, application of finite difference method, singular value decomposition method, gradient method in complex domains. – Development of algorithms for numerical solution of inverse problems by combined optimization methods, machine learning methods (neural networks, support vector machine, genetic programming, Bayesian approaches, etc.) and gradient deterministic methods in order to obtain a solution to the inverse problem with guaranteed accuracy. – Development of effective numerical methods for solving the continuation problem for the acoustics equation using quaternionic Fourier transform. – Parallelization of the above numerical methods using OpenMP and cluster computing technologies. Parallelization of iterative numerical methods for minimizing the target functional when solving continuation problems for the acoustics equation. – Conducting and analyzing numerical calculations, substantiating the numerical results obtained. Approbation of the developed numerical algorithms on the example of continuation problems arising in medical tomography, subsurface radar, in the study of wave processes.
Expected and achieved results	The results of these studies allow us to numerically solve new problems in the field of computational mathematics, namely, the construction and research of numerical difference schemes to mathematical models for inverse problems of medicine and tomography, which can be applied to the fields of dynamics, mechanics, ecology, and seismics. Develops the improvement of known results in the field of numerical optimization, namely the use of combined methods, such as evolutionary and gradient methods using parallel programming techniques, will improve the stability of solving nonlinear inverse problems. the expected scientific results during the implementation of the project will exceed the world level, both in theory and in the applied direction. The tasks set in the project are relevant, correspond to the advanced scientific level and are in many ways a priority. In addition, the scientific results have a fundamental focus on the construction and study of mathematical models of acoustic processes, which are based on partial differential equations, the study of the correctness of inverse problems for mathematical models characterized by differential equations, the development of regularization methods and the construction of algorithms for the numerical solution of inverse problems for the acoustics equation.
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List of publications with links to them	
Patents	