ANALYTICAL AND NUMERICAL METHODS OF SOLUTION TO MATHEMATICAL PHYSICS PROBLEMS

Founded in 1983.

Head of the research group: ***Ilya Vladimirovich BOYKOV****, Doctor of Physical and Mathematical Sciences, Professor.*

Members of the research group: A. I. Boykova, PhD in Physics and Mathematics, Associate Professor; N. F. Dobrynina, PhD in Physics and Mathematics, Associate Professor; T. V. Grunina (Eliseeva), PhD in Physics and Mathematics, Associate Professor; Yu. F. Zakharova, PhD in Physics and Mathematics, Associate Professor; N. P. Krivulin, PhD in Engineering, Associate Professor; N. Yu. Kudryashova, PhD in Physics and Mathematics, Associate Professor; N. V. Moyko, PhD in Engineering, Associate Professor; E. G. Romanova, PhD in Engineering, Associate Professor; V. A. Ryazantsev, PhD in Engineering, Associate Professor; M. A. Semov, Assistant; D. V. Tarasov, PhD in Engineering, Associate Professor; A. N. Tynda, PhD in Physics and Mathematics, Associate Professor; T. V. Cherusheva, PhD in Engineering, Associate Professor; P. V. Aykashev, PhD Student; Ya. V. Zelina, PhD Student.

The research group encompasses the following areas of mathematics and its applications:

1. Approximate methods for calculating singular and hypersingular integrals.

2. Approximate methods for solving weakly singular, singular, and hypersingular Fredholm and Volterra integral equations.

3. Computational methods in geophysics.

4. Approximation theory.

5. Stability and stabilisation of dynamical systems.

6. Analytical and numerical methods for identifying dynamical systems with lumped and distributed parameters.

7. Mathematical models in ecology, economics, and immunology.

Key results achieved by the members of the research group:

– Theory of cubature formulas. A general method was proposed for constructing asymptotically optimal quadrature and cubature formulas for computing weakly singular, singular, and hypersingular integrals. Formulas that are asymptotically optimal and optimal in order were developed.

– Approximate methods for solving integral and differential equations. Methods were developed for solving linear and nonlinear one- and multidimensional weak singular, singular, and hypersingular Fredholm and Volterra integral equations. In some cases, methods optimal in order, accuracy, and complexity were constructed. The research group's head solved the problem of K. I. Babenko on error asymptotics for solutions of elliptic equations.

– Approximation theory. The research group's head developed order-optimal methods for approximating and reconstructing functions from weighted Sobolev spaces, and calculated widths and entropy. The problem of calculating widths for such function – classes were posed by K. I. Babenko as one of the most important in computational mathematics and approximation theory. These results were extended by group members to other functions classes.

– Superposition methods. The research group's head solved the problem of A. N. Kolmogorov on the impossibility of representing multivariable analytic functions as superpositions of continuously differentiable functions with fewer variables.

– Motion stability and stabilisation. A general method was developed for analysing the stability of solutions to nonlinear differential equations in Banach spaces under both regular and critical conditions. This method was applied to develop sufficient stability conditions for nonlinear ordinary differential equations with delay, ordinary differential equations with small parameters in the highest derivative, and nonlinear partial differential equations.

– Identification methods. Analytical and numerical methods were developed for identifying dynamic systems described by ordinary differential equations, partial differential equations, integral convolution equations, and difference equations. Methods for identifying hereditary systems were also developed.

Approximate methods for solving direct and inverse problems in gravimetry and magnetometry.

For direct problems, the following results were obtained:

a) Development of order-optimal methods for approximating and reconstructing potential fields.

b) Development and justification of numerical methods for continuation and separation of two- and three-dimensional potential fields.

c) Development of numerical methods for transforming potential fields.

For inverse problems, the following results were obtained:

a) Development of iterative and difference methods.

b) Generalisation of the formulation of the inverse problem in gravity gradiometry. Analytical and numerical methods for simultaneously determining the boundary of a perturbance body, its density, and depth of occurrence.

Scientific results obtained by the research group's members are widely recognised nationally and internationally. The group was supported by three grants from the Ministry of Education and Science, three grants from the Russian Foundation for Basic Research, a grant from the Russian Humanitarian Science Foundation, and two grants from the International Research Foundation. The research group's members participate in federal target programmes.

Research has resulted in the publication of 15 monographs and over 500 articles.

18 dissertations were defended in the group's research field, including a Doctor of Science dissertation.