Research group 3.2.1: NATATA
Numerical Analysis, Theory of Approximations and Their Applications

Leading researcher: Bojan Popov

Current affiliation: Texas A&M University and Sofia University

SUMMIT Annual conference
Sofia University St. Kliment Ohridski
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SUMMIT
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Национален план за
възстановяване и устойчивост
НА РЕПУБЛИКА БЪЛГАРИЯ

NATATA members and areas of research

Members:

- Established researchers: Bojan Popov, Geno Nikolov, Rumen Uluchev
- Established researchers: Maya Stoyanova, Parvan Parvanov
- Established researchers: Borislav Draganov, Ivan Gadjev
- First stage researchers: Borislava Konstantinova, Georgi Bazlyankov

Research subareas:

- Area 1: Numerical methods for nonlinear hyperbolic systems
- Area 2: Classical and new inequalities in Approximation Theory
- Area 3: Approximation by linear operators in abstract function spaces
- Area 4: On min-max and max-min polarization quantities of codes and designs in polynomial metric spaces
- Area 5: Applications to Biology and Biomedicine

Overview of Research

The activity of the Research group "Numerical Analysis, Theory of Approximations and Their Applications" (NATATA) is in the general field of Applied Mathematics. The main goal of the research group is to prove original theoretical results as well as to develop new numerical methods, algorithms, and mathematical models for fundamental problems in mathematics and in various applications.

Overview of Research

Research explained in plain English

- Mathematical modeling of physical or biological phenomena
- Discretization and analysis of mathematical models
- Development of codes and simulations of physical or biological processes
- Convergence studies and error analysis of numerical algorithms
- Mathematical analysis of what an approximation model or operator can do and cannot do
- Deriving and proving universal properties for classes of approximations

Outline

Objectives

International conferences and seminars

Conferences and seminars

Members of the NATATA group participated in the following events

- Mathematics Days in Sofia 2023, plenary and invited talks
- Women in Mathematics in South-Eastern Europe
- 10th CMART Workshop, Sozopol
- Workshop on Mathematical Perspectives on Immunobiology
- Annual Airforce Meeting, AFOSR Computational Mathematics, Washington DC, USA
- Spring Scientific Session of FMI, March 23, 2024, Sofia
- Faculty of Mathematics and Informatics, Sofia University, Invited seminar
- Workshop on Mathematical Perspectives on Immunobiology, Blagoevgrad
- International Conference "Constructive Theory of Functions", Lozenets
- Multiple international conferences are planned for Summer 2024

International collaborations

Joint research with other institutions

- Texas A&M University, Vanderbilt University, USA
- Purdue University, Towson University, USA
- Institute of Mathematics, Hungarian Academy of Sciences, Budapest, Hungary
- Uppsala University, Sweden, Texas Tech University, USA
- Lawrence Livermore and Los Alamos National Laboratories, USA
- Universidad Politecnica de Madrid, Madrid, Spain
- University of Cambridge, UK

Publications during the period

Published papers:

- J.-L. Guermond, M. Nazarov, B. Popov, Finite element-based invariant-domain preserving approximation of hyperbolic systems: Beyond second-order accuracy in space, Computer Methods in Appl. Math. and Engin. Volume 418, Part A, (2024), 116470.
- Draganov, B.R. A characterization of the rate of approximation of Kantorovich sampling operators in variable exponent Lebesgue spaces, Rev. Real Acad. Cienc. Exactas Fis. Nat. Ser. A-Mat. 118, 71 (2024).
- https://biomath.math.bas.bg/biomath/index.php/biomath/article/view/j.biomath.2023.09.267

Published reports:

- http://www.math.bas.bg/nummeth/workshop2023/index.htm
- http:www.fmi.uni-sofia.bg/en/fmi-spring-science-session-2024

Work in progress

Papers submitted:

- J.-L. Guermond, M. Maier, B. Popov, L. Saavedra, I. Tomas, Greedy invariant-domain preserving approximation for hyperbolic systems, second review.
- J.-L. Guermond, B. Popov, L. Saavedra, Invariant-domain-preserving approximation of the Lagrangian hydrodynamics equations, preprint.
- I, Gadjev, P. Parvanov, R. Uluchev, Voronovskaya-type inequality and Bernstein-type inequalities for the SMK operators, submitted.
- G. Nikolov, Simple bounds for the extreme zeros of Jacobi polynomials, in preparation.
- B. Konstantinova, G. Nikolov, On the regularity of a sequence of three-row almost Hermitian incidence matrices, in preparation.
- J.-L. Guermond, B. Popov, On convergence of finite element approximations to scalar conservation laws, in preparation.
- M. Stoyanova et al., Energy bounds for weighted spherical codes and designs via linear programming, https://arxiv.org/abs/2403.07457

Technology, equipment and administration

- Supporting staff has been hired and has been very helpful.
- Portable computers, desktop computers and multifunctional devices were ordered.
- Wolfram Mathematica Computer Algebra System was requested.
- Some items are still pending, some are delivered.
- Most likely more equipment will be needed to support the computational needs of the group.

Difficulties during the first year

Key difficulties

- The group was unable to attract members and young investigators (R1) in two areas.
- The group needs to increase productivity without sacrificing quality.
- There were only a few travel visits in Bulgaria for giving research seminars due to various reasons.
- More research visits of other universities, and longer research stays are needed to foster collaborations.
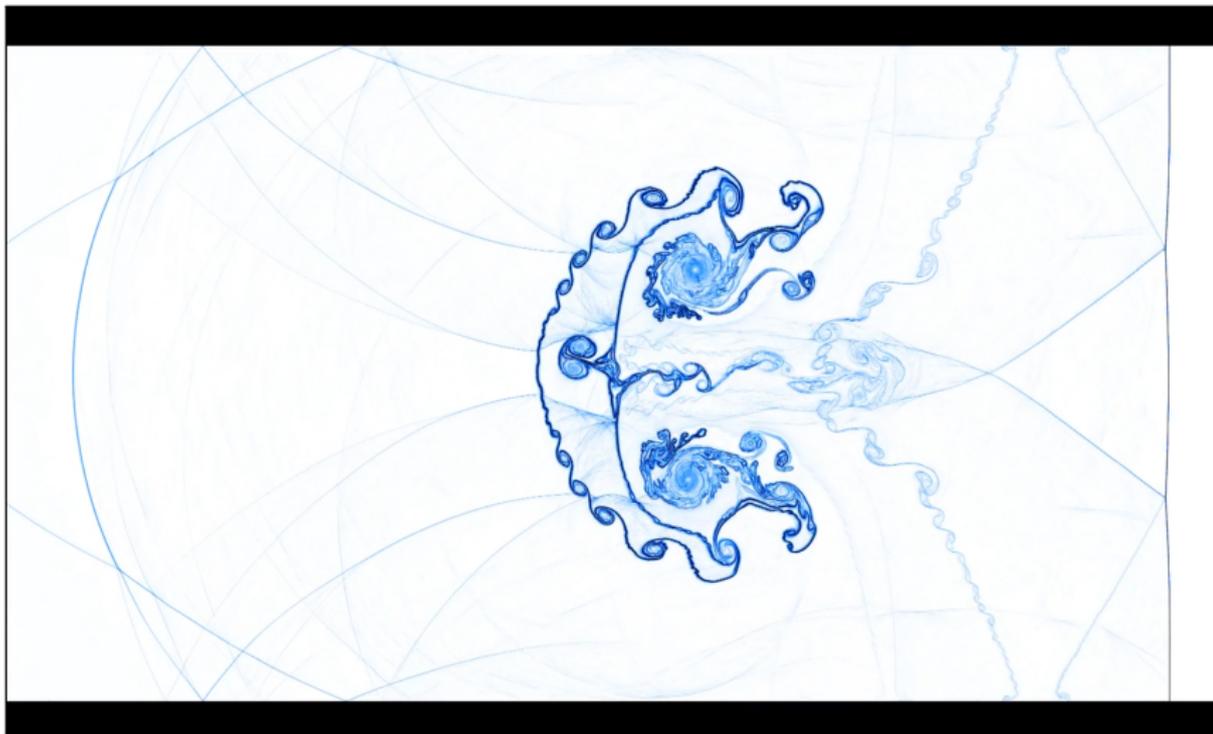- Better planning of future events is needed.

Numerical illustration

Figure: 50M dof, continuous $\mathbb{Q}_1$ elements, JWL EOS with parameters for TNT