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Probability Techniques in Analysis and Approximation Theory 2025

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НАЦИОНАЛЬНЫЕ ПРОЕКТЫ РОССИИ

НАУКА И УНИВЕРСИТЕТЫ

Preface

This brochure is a collection of abstracts of the talks presented at the conference "Probability Techniques in Analysis and Approximation Theory 2025".

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Conference website: https://www.mathnet.ru/php/conference.phtml?confid=2656

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Probability Techniques in Analysis and Approximation Theory 2025

Saint Petersburg State University, 24–29 November 2025

ABSTRACTS

TUTORIALS

On the Vertices, Facets, and Graph Diameter of Delta-Modular Polyhedra

Dmitry Gribanov (Moscow Institute of Physics and Technology and National Research University Higher School of Economics in Nizhny Novgorod)

This short tutorial is devoted to delta-modular polyhedra and their properties. A polyhedron defined by a system ($AX \leq b$) with integer (A, b) is called delta-modular if the rank-order sub-determinants of the matrix (A) are bounded in absolute value by delta. We will present results on the number of vertices and facets of such polyhedra, with special attention given to the problem of the diameter of their graph. In the latter case, we will explain a probabilistic technique for obtaining the best-known bounds on the diameter and dedicate time to open questions that may lead to improved diameter bounds.

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Network Analysis and Data Analytics in Neuro-Science

Panos Pardalos (University of Florida and National Research University Higher School of Economics in Nizhny Novgorod)

Despite considerable progress in recent years, our understanding of the fundamental principles and mechanisms that govern complex brain function and cognition remains insufficient. Network neuroscience presents a novel perspective to tackle these persistent challenges by explicitly embracing an integrative approach to investigating the structure and function of the brain.

In this lecture we will discuss network analysis for the Parkinson brain using fMRI data, and network analysis for the epileptic brain using EEG data. In addition we will discuss network controllability applied to the brain.

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TALKS

De Branges spaces and local description of submodules of entire functions

Natal'ya Abuzyarova (Institute of Mathematics with Computing Centre of RAS, Ufa)

We present a scheme of using de Branges spaces theory to study the local description problem for submodules in different spaces of entire functions. Among other things this scheme includes the development of ideas from the paper by Anton Baranov and Yurii Belov (2019). They used de Branges theory as the toolbox for exploring, although in other terms, some unsolved questions on submodules of entire functions which are Fourier-Laplace transforms of compactly supported distributions.

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Weakly compact and Deutsch compact sets in approximation theory. Application to exponential sums.

Alexey Alimov (St. Petersburg State University and Lomonosov Moscow State University)

Approximative compactness type properties in problems of min- and max-approximation are studied, in this way, CLUR, Day–Oshman, Anderson–Megginson, CMLUR and AT classes of spaces arise naturally. These spaces are characterized in approximative terms. In particular, we characterize the spaces with max-approximatively compact unit ball and the spaces with approximatively compact unit ball, we also obtain results on min- and max-approximative compactness for suns and max-suns.

In addition, the following problems of min- and max-approximation are solved:

(1) characterization of the spaces where each closed neighborhood of each convex existence set is approximatively compact;

(2) characterization of the spaces where each closed neighborhood of each convex existence set is an approximatively weakly compact *Chebyshev set*;

(3) characterization of the spaces where each closed neighborhood of each is approximatively weakly compact set is approximatively weakly compact;

(4) characterization of the spaces where the classes of strongly and weakly approximatively compact sets coincide;

(5) characterization of the spaces where where the classes of strongly and weakly max-approximatively compact sets coincide;

(6) characterization of the spaces where each sun (max-sun) is approximatively weakly compact (max-approximatively weakly compact);

(7) characterization of the spaces such that each point of the space, except the origin, is a point of weak max-approximative compactness of the unit ball.

Various classes of exponential sums are proved to be monotone path-connected / Menger-connected. The set of extended exponential sums is shown to be a sun in $C[a,b]$.

The results were obtained by the author in collaboration with Prof. I.G. Tsar'kov.

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On constructing probabilistic operator-valued measures from frames in a Hilbert space

Grigori Amosov (Steklov Mathematical Institute of RAS, Moscow)

Probabilistic operator-valued measures generated by frames and their applications in information theory are discussed.

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Ensembles of random matrices and applications to Brownian bridges, Laplacian growth

Alexander Aptekarev (Keldysh Institute of Applied Mathematics of RAS, Moscow)

We discuss a connection between ensembles of random matrices, in particularly the limiting distributions of their eigenvalues, with applications to diffusion models. Firstly we touch Brownian bridges (related with the Gaussian Unitary Ensembles with External Sources) and their application to machine learning diffusion models. Then we switch to the Normal Matrices Ensembles, which complex valued eigenvalues perform a model of the Laplacian Growth in 2-D hydrodynamics and Diffusion limited aggregation (when size of matrices tends to infinity). The main tool in our analysis is asymptotic theory for orthogonal and multiple orthogonal polynomials.

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Information Diffusion on Graphs with Exogenous News Flow

Vladimir Balash (Saratov State University)

We consider the case when at each time step a certain number of graph nodes change their state under the influence of an exogenous news flow. A model of a competitive information process on undirected graphs is proposed. Empirical distributions of the number of vertices reached by a state, the number of news items circulating through the graph, and some other metrics are investigated.

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The Polyak-Lojasiewicz condition for a Lipschitz differentiable function on a smooth manifold

Maxim Balashov (Institute of Control Sciences RAS, Moscow)

The Polyak-Lojasiewicz condition in unconstrained minimization ensures convergence with the rate of geometric progression of the gradient descent method, random coordinate descent, and a number of other algorithms for Lipschitz-differentiable and, in general, nonconvex functions. This condition is also closely related to some other properties of the function being minimized. We shall discuss a similar property for a Lipschitz differentiable function on a smooth compact manifold. The relationship with other conditions and the rate of convergence of the gradient projection method will be considered.

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On L-special domains with algebraic boundaries

Mikhail Borovikov (St. Petersburg State University)

The concept of L-special domain appeared in the early 2000s. This analytical characteristic of domains in the complex plane is related to the problem on uniform approximation of functions on Carathéodory compacts in $\mathbb{R}^2$ by polynomial solutions of homogeneous second-order elliptic partial differential equations $Lu = 0$ with constant complex coefficients. We obtain new properties and examples of L-special domains with algebraic boundaries.

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Borel transformations of random fields

Alexander Bufetov (St. Petersburg State University and Steklov Mathematical Institute of RAS, Moscow)

In working with the Gaussian Multiplicative Chaos, one encounters various families of Borel transformations of random fields — such as, for instance , the normalized exponential or the truncated normalized exponential used by Nathanael Berestycki. The main result of this talk gives sufficient conditions ensuring the continuity in distribution for Borel transformations of random fields. The talk is based on the paper, "Continuity in distribution for Borel transformations of random fields", Theory of prob. and appl., 70:4 (2025), 663–671.

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On generalised Gaussian quadratures

Aleksandr Dyachenko (Keldysh Institute of Applied Mathematics of RAS, Moscow),
Vladimir Lysov (Keldysh Institute of Applied Mathematics of RAS, Moscow)

C.F. Borges proposed to use quadrature rules of Gaussian type for simultaneous calculation of integrals with respect to several weights. This approach is especially beneficial when calculation of the integrand is a relatively expensive operation. Typical applications however only deal with AT-systems of weights. With our co-authors, we are interested in studying other systems of weights, which seem to have nice applications. In particular, we study Gaussian-type quadrature rules for certain Angelesco systems and consider properties of their averaged versions.

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Approximation by simplest fractions and simplest bianalytic fractions

Konstantin Fedorovskiy (St. Petersburg State University and Lomonosov Moscow State University)

This talk will examine issues of uniform approximation of functions in domains and on compact sets in the complex plane by sums of analytic kernels (which can be fundamental solutions of various elliptic differential equations, reproducing kernels of various spaces of analytic functions, and other similar analytic objects). Importantly, the approximation aggregates are sums with unit coefficients (such sums are often called simplest or quantized ones). Particular attention will be paid to approximation by simplest fractions (sums of Cauchy kernels) and approximation by simplest bianalytic fractions (sums of bianalytic kernels-fundamental solutions to the Bitsadze equation). Recent results and open problems will be presented.

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The concept of support and its application to the classification of function spaces

Leonid Genze (Tomsk State University)

The report will discuss the concept of the support of a point y of a Tychonoff space Y under a linear mapping $C(X) \mapsto C(Y)$, different ways of defining it, and how this concept is used to classify function spaces.

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Diagonal Frobenius Number via Gomory Relaxation and Discrepancy

Dmitry Gribanov (Moscow Institute of Physics and Technology and National Research University Higher School of Economics in Nizhny Novgorod),
Nikita Kasyanov (Laboratory of Algorithms and Technologies for Network Analysis, National Research University Higher School of Economics in Nizhny Novgorod)

In this work, we consider an ILP problem of the form: find a non-negative integer vector (x) satisfying the system $(Ax = b)$ with given integer inputs (A, b). The following fact is known: if the system $(Ax = b)$ has a non-negative real solution x whose components are all sufficiently large, then the system also has a non-negative integer solution (z). The minimal required magnitude of the components of (x) is called the diagonal Frobenius number of the matrix (A) and represents a natural generalization of the classical Frobenius number. Moreover, under stronger conditions on the magnitude of the components of (x), the corresponding solution (z) can be found by a polynomial-time algorithm. As our main result, we present new bounds on the diagonal Frobenius number, which significantly improve all previously known bounds, including those for the polynomially solvable case.

The talk is based on a joint work with Nikita Kasyanov.

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Introduction to Integer Points Counting in Polytopes

Mario Rosario Guarracino (University of Cassino and Southern Lazio, Italy, and National Research University Higher School of Economics in Nizhny Novgorod)

Networks provide a natural framework to model interactions and dependencies across complex systems – from biological and social networks to financial and communication infrastructures. This talk presents a statistical perspective on learning from networked data, focusing on how nodes, subgraphs, and entire graphs can be efficiently represented in low-dimensional vector spaces. Starting from classical graph statistics and shallow embeddings, we move toward modern encoder-decoder architectures and graph neural networks (GNNs), highlighting their strengths, limitations, and interpretability challenges. We also explore recent advances in whole-graph embedding and graph transformer models, discussing their applications in real-world scenarios such as biomedical network analysis. Finally, open research directions in expressivity, generalization, and optimization are outlined, connecting theoretical insights with emerging opportunities in graph machine learning.

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Liouville type phenomenon for the Klein-Gordon equation

Håkan Hedenmalm (St. Petersburg State University)

Liouville's theorem is the basic "collapse" theorem, where an entire bounded function must be constant. A similar phenomenon is the Phragmen-Lindelof principle which says that if a holomorphic function does not grow sufficiently near a boundary point, it must be bounded there. Here we extend the realm of such statements to the Klein-Gordon equation in 1+1 dimensions, a prototypical hyperbolic partial differential equation. This reports on joint work with A. Bakan.

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On Bernstein- and Markov-type inequalities on compact sets of the unit circle

Sergei Kalmykov (Shanghai Jiao Tong University)

First, we consider covering and distortion theorems for polynomials normalized on a union of circular arcs, and as corollaries, results on polynomials with additional constraints on zeros. Then, we discuss a special form of an asymptotically sharp Markov-type inequality on rather general compact sets on the unit circle. The talk is based on joint works with V.N. Dubinin and K. Konoplev.

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Uncertainty of Tensor Graphical Model Selection

Valeriy Kalyagin (National Research University Higher School of Economics in Nizhny Novgorod),
Ilya Kostylev (National Research University Higher School of Economics in Nizhny Novgorod)

Graphical modeling is a powerful tool for various applied research. Usually, graphical models are associated with some multivariate (vector) distribution including Gaussian and others. It means that for each entity within a dataset, each feature would be a univariate random variable (scalar). However, in some applications, it may be beneficial to represent features associated with a single entity as multidimensional random variables. This idea leads to tensor graphical models where the dataset is given as tensor data, for example, vectors (1st order tensor, classic graphical models), matrices (2nd order tensor) or tensors of higher order. A key question is: what is the relationship between the expected quality of tensor graphical model selection and the edge density of true underlying graph? In this talk, we will present the results of the uncertainty analysis of one of the popular tensor graphical model selection algorithms, TLasso.

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Distribution of zeros of entire and holomorphic functions on the unit disk with restrictions on their growth from above

Bulat Khabibullin (Institute of Mathematics with Computing Centre of RAS, Ufa)

Let M be a function on a domain D of the complex plane $\mathbb{C}$ with values in the extension $\overline{\mathbb{R}} := \mathbb{R}\cup\{\pm\infty\}$ of the real axis $\mathbb{R}$, and let Z be a distribution of points on D. Two similar but different problems will be discussed — to describe the conditions for the existence of a nonzero function f holomorphic on D with the bound $|f| \leq \exp M$ and with the property: 1) the distribution of zeros of the function f coincides with Z or 2) the function f vanishes on Z (all taking into account the multiplicities of zeros). First, our criteria will be formulated for these problems. Approaches to the proof of these criteria also use the apparatus of abstract potential theory (balayage=sweeping out, duality, etc.) by some analogy with probability-theoretic methods. Next, we will consider some aspects of these criteria for cases where the domain D is the plane $\mathbb{C}$ or the open unit disk $\mathbb{D}$ in $\mathbb{C}$. The main goals of this adaptation are to achieve clarity and geometrization of the criteria, taking into account the invariance of the plane $\mathbb{C}$ and the disk $\mathbb{D}$ with respect to rotation centered at the origin.

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Significant conclusions on the dynamics of the market graph

Petr Koldanov (National Research University Higher School of Economics in Nizhny Novgorod),
Alexander Koldanov (National Research University Higher School of Economics in Nizhny Novgorod),
Elena Tsygankova (National Research Tomsk Polytechnic University)

This work addresses the problem of detecting the dynamics of the market graph. The key question is whether observed changes in the market graph are systematic or can be explained by random fluctuations in correlation estimates. A method is proposed to obtain statistically significant conclusions about the presence of market graph dynamics. This method builds on a recently developed approach for identifying sets of statistically significant inferences regarding the existence or absence of correlations of a specific strength between each pair of stocks. According to the method a decision on the presence of dynamics is made if at least one pair of stocks in one observation period is classified as having a significant correlation while in another period it is classified as lacking a significant correlation. The proposed approach allows identifying pairs of stocks responsible for the market graphs dynamics, pair whose correlation changes do not lead to such dynamics and an area of uncertainty. Examples of applying the method to analyze the dynamics of the market graph constructed for key stocks of the Russian stock market are provided.

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On the precise form of the inverse Markov inequality for convex sets

Mikhail Komarov (Vladimir State University)

Let $\Pi_n(K)$ be the class of polynomials of exact degree n, all of whose zeros lie in a convex compact set $K \subset \mathbb{C}$. The Turán type inverse Markov factor $M_n(K)$ is defined by $M_n(K) = \inf_{P\in\Pi_n(K)} \left(\|P'\|_{C(K)}/\|P\|_{C(K)}\right)$. Extending two well-known results due to Levenberg and Poletsky (2002) and Révész (2006), we obtain (up to a constant factor) the precise form of $M_n(K)$ in terms of n, d and w, where $d > 0$ is the diameter and $w \geq 0$ is the minimal width of K.

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Hermite–Padé polynomials in the model case

Aleksandr Komlov (Steklov Mathematical Institute of RAS, Moscow)

By the model case we mean the situation where we consider Hermite–Padé polynomials for a tuple $[1, f_0, f_0^2]$, where f_0 is a germ of 3-valued algebraic function f. This model case was first time investigated by J. Nuttall in 1981. In 1984 he showed how to recover two values of our 3-valued algebraic function f with the help of Hermite–Padé polynomials in question. But his proofs had gaps and were given not in general case. These disadvantages were removed in the joint work by E. Chirka, R. Palvelev, S. Suetin, A. Komlov in 2017. In the talk we discuss this result and other results on the properties of these Hermite–Padé polynomials. In particular, we discuss asymptotic properties of the corresponding discriminants (joint result with R. Palvelev) and the interpolation points.

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Artificial intelligence methods for Cayley graphs

Elena Konstantinova (Sobolev Institute of Mathematics, Mathematical Center in Akademgorodok, Novosibirsk, and Three Gorges Mathematical Research Center, China Three Gorges University, Yichang)

In this talk we review some new results obtained by using AI methods to check open problems in Cayley graph theory and to state new conjectures. The results discussed in the talk are published in https://arxiv.org/abs/2509.19162.

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Generalization of the Julia–Carathéodory theorem and its applications

Olga Kudryavtseva (St. Petersburg State University and Lomonosov Moscow State University)

We study holomorphic self-maps of the unit disk with boundary fixed points. In 1982, Cowen and Pommerenke established an interesting generalization of the classical Julia–Carathéodory theorem, which allowed them to derive a sharp estimate for the derivative at the Denjoy–Wolff point on the class of functions with an arbitrary finite set of boundary fixed points. In this talk, we present a new generalization of the Julia–Carathéodory theorem, which contains the Cowen–Pommerenke result as a special case; moreover, it is an effective tool for solving various problems on classes of functions with fixed points.

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Generalized Euclidean algorithm and criterion of total non-negativity of generalized Hurwitz matrices

Olga Kushel (Belarusian State University, Minsk)

Given a set of real numbers $a_0, \ \ldots, \ a_n$ and a positive integer M, $1 \leq M \leq n$, a generalized Hurwitz matrix is defined as follows

$$H_M = \{h_{ij}\}_{i,j=1}^{\infty},$$

where $h_{ij} = a_{Mj-i}, \ i,j = 1, \ 2, \ \ldots$, and $a_i = 0$ for $i < 0$ or $i > n$. We establish a criterion of total nonnegativity (i.e. non-negativity of all the minors) of the infinite-dimensional matrix H_M, in terms of positivity of finitely many its "special"minors. Basing on this criterion, we construct a factorization of totally nonnegative matrix H_M. The crucial aspect of our results, is the modification of the generalized Euclidean algorithm with step M, which is of independent interest. We focus on the connection between the generalized Euclidean algorithm with step M and the Gaussian elimination process, applied to the generalized Hurwitz matrix H_M.

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Poncelet's Closure Theorem and compositions of finite Blashke Products

Kirill Lenskiy (St. Petersburg State University)

We will briefly discuss the connection between generalized Poncelet's curves and Blashke Products (see "Poncelet-Darboux, Kippenhahn, and Szegő: interactions between projective geometry, matrices and orthogonal polynomials M. Hunziker, A. Martinez-Finkelshtein, T. Poe, and B. Simanek). Then I will introduce a result concerning the behaviour of Blashke products in the classic elliptical case and its applications.

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A discussion about the mathematics underlying artificial neural networks (ANN) and some examples of ANNs applications.

Anton Lizunov (Moscow Institute of Physics and Technology)

The report will consider the mathematical model of ANN as a multiparametric function of a special kind approximating a target function. The ANN learning process is considered as the task of selecting the ANN parameters that provide the best approximation of the target function. The feature of the ANN structure as a function of a set of parameters is analyzed, which makes it possible to relatively quickly calculate the derivatives of the discrepancy with the target function according to the ANN parameters and, thus, minimize this discrepancy using gradient methods. The report also examines some examples of the ANNs application.

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Hexagon tilings with $m \times m$ periodic weightings

Elijah Lopatin (Steklov Mathematical Institute of RAS, Moscow)

Recent studies have investigated the asymptotic behavior of Determinantal Point Processes arising from hexagonal tilings with periodic weightings, employing matrix-valued orthogonal polynomials. In the specific case of triple periodic weightings, A. B. J. Kuijlaars has characterized the corresponding asymptotics using an equilibrium measure for a scalar potential problem with an external field on a genus one Harnack spectral curve (arXiv:2412.03115v1). In this talk, we present a solution to the weak asymptotic problem for matrix-valued orthogonal polynomials associated with tilings of arbitrary periodicity m. The proof utilizes the Passare-Leinartas-Tsikh theorem concerning the asymptotic behavior of solutions to multidimensional difference equations. Our solution is expressed in terms of the amoeba of a Harnack spectral curve of genus $g > 1$.

This work was supported by the Russian Science Foundation under grant no. 24-11-00196, https://rscf.ru/en/project/24-11-00196/.

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On a formula for characteristic determinant of a boundary value problem for $n \times n$ Dirac type system

Mark Malamud (St. Petersburg State University and Institute of Applied Mathematics and Mechanics, Donetsk)

Consider the following $n \times n$ Dirac type equation:

$$-iy' - iQ(x)y = \lambda B(x)y, \qquad y = \mathrm{col}(y_1, \ldots, y_n), \qquad x \in [0, \ell], \tag{1}$$

on a finite interval $[0, \ell]$ subject to the general two-point boundary conditions

$$Cy(0) + Dy(\ell) = 0, \quad C, D \in \mathbb{C}^{n \times n}, \quad \mathrm{rank}(CC^* + DD^*) = n \tag{2}$$

Here $Q = (Q_{jk})_{j,k=1}^n$ is an integrable potential matrix and $B = \operatorname{diag}(\beta_1, \ldots, \beta_n) = B^*$ is a diagonal integrable matrix "weight". If $n = 2m$ and $B(\cdot) = \operatorname{diag}(-I_m, I_m)$, this equation turns into the classical $n \times n$ Dirac equation.

In this talk we discuss the spectral properties of the boundary value problems (BVP) (1)–(2). The key role in our investigation is playing the following representation of the characteristic determinant $\Delta_Q(\cdot)$ of the BVP (1)–(2):

$$\Delta_Q(\lambda) = \Delta_0(\lambda) + \int_{b_-}^{b_+} g(u) e^{i\lambda u}\, du, \qquad g \in L^1[b_-, b_+], \tag{3}$$

Here $\Delta_0(\cdot)$ is the characteristic determinant of the unperturbed BVP ($Q = 0$) and $b_\pm$ are explicitly expressed via entries of the matrix function $B(\cdot)$. Formula (3) is valid under certain assumptions on $\{\beta_k(\cdot)\}_1^n$ and Q. In particular, *it holds for* $B = B^* = const$. In this case the implication $Q \in L^p[b_-, b_+] \otimes \mathbb{C}^{n\times n} \Longrightarrow g \in L^p[b_-, b_+]$ holds. In the case of $B = \operatorname{diag}(b_1, b_2) =$ const formula (3) is obtained in [1].

In turn, under certain assumption on $\{\beta_k(\cdot)\}_1^n$ formula (3) yields asymptotic behavior of the spectrum in the case of regular boundary conditions. Namely, we show that $\lambda_m = \lambda_m^0 + o(1)$ as $m \to \infty$, where $\{\lambda_m\}_{m\in\mathbb{Z}}$ and $\{\lambda_m^0\}_{m\in\mathbb{Z}}$ are sequences of eigenvalues of perturbed and unperturbed BVPs, respectively. It is also shown that for $Q \in L^p$, $p \in (1, 2]$, (and constant B) the following estimate holds:

$$\sum_{m\in\mathbb{Z}} |\lambda_m - \lambda_m^0|^{p'} + \sum_{m\in\mathbb{Z}} (1 + |m|)^{p-2} |\lambda_m - \lambda_m^0|^p < \infty, \qquad p' := p/(p-1).$$

The talk is based on a joint paper [2] with Anton Lunyov.

References

1. *A.A. Lunyov and M.M. Malamud*, On the Riesz basis property of root vectors system for 2×2 Dirac type operators, *J. of Math. Anal., Appl.*, 441,: 57–103, 2016.

2. *A.A. Lunyov and M.M. Malamud*, On the formula for characteristic determinants of BVP for $n \times n$ Dirac type systems, *Advances in Math.*, **478** (2025), 110389.

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On Recent Advances in Graph-based Approximate Vector Search

Dmitry Malyshev (National Research University Higher School of Economics in Nizhny Novgorod and Lobachevsky State University, Nizhny Novgorod)

Vector search, which returns the vectors most similar to a given query vector from a large vector dataset, underlies many important applications such as search, recommendation, and LLMs. To trade for efficiency, approximate vector search is usually used in practice, which returns most rather than all of the top-k nearest neighbors for each query. In this talk, an introduction to vector search and to existing methods in it will be made, with emphasis on graph-based algorithms. Additionally, KBEST, our vector search library, will be presented, tailored for the latest Huawei Kunpeng 920 CPUs. It up to 2x times outperforms known SOTA vector search libraries, running on x86 CPUs.

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Kirchhoff index for circulant foliations of graphs

Alexander Mednykh (Sobolev Institute of Mathematics, Novosibirsk, and Novosibirsk State University)

A new approach is presented for obtaining closed analytic formulas for the Kirchhoff index for circulant foliations of graphs. The simplest examples of such foliations are circulant graphs. More complex examples include prism graphs, sandwich graphs, discrete tori, and many others.

This paper derives explicit analytic formulas for the Kirchhoff index and studies their asymptotic behavior. Results are published in [1, 2].

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Optimal stability estimates for certain convex functionals on weighted Bergman spaces with applications

Petar Melentijević (University of Belgrade)

Very recently, Kulikov proved sharp contractive estimates for convex functionals on weighted Bergman spaces. In this paper we prove sharp quantitative stability estimates for this functionals. We present several applications - recovering the appropriate result in the context of Fock spaces, its Hardy space counterpart (functionals induced by an increasing function), application to wavelet transform.

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An Interpolating Function for Power Series Coefficients and the Mellin Transform of the Sum

Aleksandr Mkrtchyan (Siberian Federal University, Krasnoyarsk, and Institute of Mathematics NAS RA)

We consider a one-dimensional power series with a non-zero radius of convergence, centered at zero. A connection is established between the analytic continuation of the power series via coefficient interpolation and its Mellin transform. For rational functions, the Mellin transform can be represented as a product of gamma functions and an entire function of exponential type. Using an interpolating function, this class can be extended.

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Analysis of photon-counting probability distributions attached to Landau levels on the Poincaré disk

Zouhair Mouayn (Sultan Moulay Slimane University, Morocco)

To each hyperbolic Landau level of the Poincaré disc is attached a generalized negative binomial distribution. In this paper, we compute the moment generating function of this distribution and supply its atomic decomposition as a perturbation of the negative binomial distribution by a finitely supported measure. Using the Mandel parameter, we also discuss the nonclassical nature of the associated coherent states. Next, we derive a Lévy-Khintchine-type representation of its characteristic function when the latter does not vanish and deduce that it is quasi-infinitely divisible except for the lowest hyperbolic Landau level corresponding to the negative binomial distribution. By considering the total variation of the obtained quasi-Lévy measure, we introduce a new infinitely divisible distribution for which we derive the characteristic function.

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Paley-Wiener-Schwartz type theorems for function spaces on an unbounded closed convex set and their applications

Ildar Musin (Institute of Mathematics with Computing Centre of RAS, Ufa)

In the talk there will be considered some problems of operator theory and Fourier analysis in spaces of rapidly decreasing functions on unbounded convex sets of a multidimensional real space of the form

$$U(b,C) = \{\xi \in \mathbb{R}^n : -\langle \xi, y \rangle \ \leq b(y), \, \forall y \in C\},$$

where C is an open convex acute cone in $\mathbb{R}^n$ with the vertex at the origin, b is a convex continuous positively homogeneous of order 1 function on $\overline{C}$.

One of the problems is as follows. For an unbounded closed convex set $\Omega \subset \mathbb{R}^n$ ($\Omega \neq \mathbb{R}^n$) let $S(\Omega)$ be the Schwartz space on Ω. Let $D \subset \mathbb{R}^n$ be a bounded convex domain, K is a closure of D, $G = U(b,C) + K$. Let μ be a linear continuous functional on $C^\infty(K)$. The operator $M_\mu : f \in S(G) \to \mu * f$ acts from $S(G)$ into $S(U)$. The problem is to find conditions for surjectivity of the operator M_μ.

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On iterations of the Cauchy-Fantappié transform of analytic functionals

Simona Myslivets (Siberian Federal University, Krasnoyarsk),
Aleksandr Kytmanov (Siberian Federal University, Krasnoyarsk)

We consider the Cauchy-Fantappié integral representation of a certain form $Q[f]$ for real analytic functions f on the boundary of a bounded domain D with real analytic connected boundary Γ in the complex space $\mathbb{C}^n$, $n > 1$. Its kernel consists on derivatives of the fundamental solution of the Laplace equation. Previously, the authors considered iterations of this integral operator $Q^m[f]$ for smooth functions f and showed that they converge to a holomorphic function as $m \to \infty$.

Here we define the Cauchy-Fantappié transform $Q[T](z)$ for analytic functionals T. We prove that the iterations $Q^m[T](z)$ converge to the CR-functional as $m \to \infty$.

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Conflict-Minimizing Gradient Selection for Multi-Task Learning

Gleb Neshchetkin (National Research University Higher School of Economics in Nizhny Novgorod)

Machine Learning (ML) models are typically trained on data for a single target task, with the goal of optimizing performance for that specific task. In contrast, multi-task learning (MTL) aims to train a single model on data from multiple tasks simultaneously, where a shared model representation is learned across all tasks. MTL is widely applied across various domains, including natural language processing and computer vision, but training multiple tasks together introduces significant challenges. MTL is a multi-objective optimization problem, different tasks often have competing objectives, leading to conflicts in gradient updates. Conflict management is critical in this case to facilitate effective learning. A key challenge lies in selecting an optimal update direction that balances the trade-offs between competing tasks without compromising overall model performance. This study presents a comparative analysis of methods for handling gradient interference in MTL. It examines different strategies for selecting a single optimal direction in multi-objective optimization. The algorithms are tested on computer vision tasks using the CityScapes and NYU-v2 datasets and the GLUE benchmark for natural language processing, providing a comprehensive evaluation of the effectiveness of these approaches.

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Diagonals of Laurent series of rational functions and their integral representations

Dmitrii Pochekutov (Siberian Federal University, Krasnoyarsk)

Generating functions naturally split into nested classes: rational, algebraic, and D-finite [1]. Consider a rational function of n complex variables and its Laurent series expansion centered at the origin. The generating function of the subsequence obtained by restricting the sequence of coefficients of this Laurent series to a certain sublattice is called the diagonal of the Laurent series. This construction yields a rich family of functions widely represented in enumerative combinatorics [2], mathematical physics [3], and statistical physics [4].

In our talk, we discuss how integral representations for diagonals help determine their place within the mentioned hierarchy and describe their singular points and branching behavior.

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Building a Logistics Network with Non-linear Edge Costs and Transfers

Alexander Ponomarenko (National Research University Higher School of Economics in Nizhny Novgorod)

This presentation will cover the organization of the cargo transportation system for Russia's largest marketplace. I will discuss the various challenges we encountered while solving this problem and how we overcame them.

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On the value-distribution theorems for a class of L-functions

Irina Rezvyakova (Steklov Mathematical Institute of RAS, Moscow)

It is known that the values of $\log\zeta(1/2+it)$ are asymptotically Gaussian distributed. Namely, for any set $B \in \mathbb{C}$ of positive Jordan content, we have

$$\frac{1}{T}\ \text{meas}\ \{t \in [T; 2T] : \frac{\log\zeta(\frac{1}{2}+it)}{\sqrt{\pi\log\log T}} \in B\} \sim \int\int_B e^{-\pi(x^2+y^2)}dxdy.$$

We shall talk about the proof of this type results for a class of L-functions and their applications (developed by Atle Selberg) to other problems on zeros of L-functions.

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Quantum Trace and Dehn filling

Mauricio Romo (Shanghai Institute for Mathematics and Interdisciplinary Sciences (SIMIS))

I will briefly introduce the quantum trace map for hyperbolic links in the 3-sphere and its expectation value, computed by the SL(2,C) Chern-Simons theory. I will argue, using the example of Dehn filling of the Whitehead link, that the operation of taking the expectation value of the quantum trace and Dehn filling commutes, at least, at the level of asymptotics of partition functions.

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Universal frame set for rational functions

Andrei Semenov (St. Petersburg State University)

For $(\lambda, \mu) \in \mathbb{R}^2$ define a time-frequency shift operator $\pi_{\lambda,\mu}$ on $L^2(\mathbb{R})$ by the rule

$$\pi_{\lambda,\mu} g(t) := e^{2\pi i\lambda t} g(t-\mu), \quad g \in L^2(\mathbb{R}).$$

Now for a fixed $g \in L^2(\mathbb{R})$ and countable $L \subset \mathbb{R}^2$ we define a *Gabor system* $\mathcal{G}(g, L)$ as follows:

$$\mathcal{G}(g, L) := \{\pi_{\lambda,\mu} g \mid (\lambda, \mu) \in L\}.$$

The system $\mathcal{G}(g, L)$ is a *Gabor frame* if for some constants $A, B > 0$ one has

$$A\|f\|_2^2 \le \sum_{(\lambda,\mu)\in L} |(f, \pi_{\lambda,\mu} g)|^2 \le B\|f\|_2^2, \text{ for any } f \in L^2(\mathbb{R}). \tag{4}$$

Definition 1. For any $M \in \mathbb{N}$ let $\mathcal{K}_1(M)$ be a class of rational functions of degree M, i.e. it has the form

$$g(t) = \sum_{k=1}^{N} \frac{a_k}{(t - iw_k)^{j_k}}, \text{ where } a_k \in \mathbb{C}, w_k \in \mathbb{C} \setminus i\mathbb{R} \text{ and } \sum_{k=1}^{N} j_k = M,$$

such that

$$\sum_{k=1}^{N} a_k e^{2\pi w_k t} \frac{(2\pi i)^{j_k-1}}{(j_k-1)!} t^{j_k-1} \neq 0 \text{ for any } t < 0. \tag{5}$$

For example, if all the poles of g lie in the upper half-plane, then (5) is equivalent to the simple condition

$$\widehat{g}(t) \neq 0 \text{ for any } t > 0. \tag{6}$$

Definition 2. For a set L its *upper density* $D(\Lambda)$ is defined by the formula

$$D(\Lambda) = \lim_{a\to\infty} \sup_{R\in\mathbb{R}} \frac{\#\{x \in \Lambda \mid x \in [R, R+a]\}}{a}.$$

In the talk we discuss the following universal result:

Theorem 1. *For any $\varepsilon > 0$ and any $M \in \mathbb{N}$ there exist a set $\Lambda = \Lambda(\varepsilon, M) \subset \mathbb{R}$ of density $D(\Lambda) \le 1 + \varepsilon$ such that the system*

$$\mathcal{G}(g, \Lambda \times \mathbb{Z}) := \{e^{2\pi i\lambda t} g(t-n) \mid (\lambda, n) \in \Lambda \times \mathbb{Z}\}$$

is a frame in $L^2(\mathbb{R})$ for any rational function $g \in \mathcal{K}(M)$.

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On topological properties of graphene

Armen Sergeev (St. Peresburg State University and Steklov Mathematical Institute, Moscow)

This is a report on the topological properties of graphene. We start from the description of the structure of graphene and its Hamiltonian. We consider next the topological invariant of graphene, called the eigenspace vorticity, introduced by Monaco and Panati and computed for the 1-canonical model.

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A Riemann-Hilbert problem for Jacobi-Pineiro orthogonal polynomials

Vinay Shukla (School of Mathematical Sciences, Shanghai Jiao Tong University),
Vladimir Lysov (Keldysh Institute of Applied Mathematics of RAS, Moscow),
Sergei Kalmykov (Shanghai Jiao Tong University)

We investigate the asymptotic behaviour of Jacobi-Pineiro polynomials of degree $2n$ orthogonal on $[0, 1]$ with respect to weights $w_j(x) = x^{\alpha_j}(1-x)^\beta$, $j = 1, 2$ where $\alpha_1, \alpha_2, \beta > -1$, and $\alpha_1 - \alpha_2 \in (0, 1)$. These polynomials are characterized by a Riemann-Hilbert problem for a 3×3 matrix valued function. We use the Deift-Zhou steepest descent method for Riemann-Hilbert problems to obtain strong uniform asymptotics in the complex plane. The local parametrix around the origin is constructed using Meijer G-functions. We match the local parametrix around the origin with the global parametrix with a double matching, a technique that was recently introduced.

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Models of Bipartite Graph Evolution

Sergey Sidorov (Saratov State University)

Many real-world networks evolve dynamically through processes such as merging, reconnection, and link duplication. This talk will introduce a family of iterative stochastic models for bipartite network evolution based on these mechanisms. We will characterize the resulting networks, including analytical derivations for the degree distributions in the limiting graphs, and compare these results with simulations.

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On the convergence conditions of a weak greedy algorithm

Aleksei Solodov (St. Petersburg State University and Lomonosov Moscow State University)

This report is devoted to the convergence of a weak greedy algorithm, which is used to find an m-term approximation of an arbitrary element of a Hilbert space by elements of a normalized dictionary. V.N. Temlyakov and E.D. Livshits obtained convergence conditions for this algorithm depending on the behavior of the elements of the weakening sequence. We present new necessary and sufficient conditions for the convergence of a weak greedy algorithm, as well as a criterion for its convergence in the case of a quasi-monotone weakening sequence.

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Ricci flow approaches to community detection on graphs

Konstantin Sorokin (National Research University Higher School of Economics in Saint Petersburg)

Community detection in complex networks is a fundamental problem, open to new approaches in various scientific settings. We introduce a novel community detection method, based on Ricci flow on graphs. Our technique iteratively updates edge weights (their metric lengths) according to their (combinatorial) Foster version of Ricci curvature computed from effective resistance distance between the nodes. The latter computation is known to be done by pseudo-inverting the graph Laplacian matrix. At that, our approach is alternative to one based on Ollivier-Ricci geometric flow for community detection on graphs, significantly outperforming it in terms of computation time. In our proposed method, iterations of Foster-Ricci flow that highlight network regions of different curvature – are followed by a Gaussian Mixture Model (GMM) separation heuristic. That allows to classify edges into "strong" (intra-community) and "weak" (inter-community) groups, followed by a systematic pruning of the former to isolate communities. We benchmark our algorithm on synthetic networks generated from the Stochastic Block Model (SBM), evaluating performance with the Adjusted Rand Index (ARI). Our results demonstrate that proposed framework robustly recovers the planted community structure of SBM-s, establishing Ricci-Foster Flow with GMM-clustering as a principled and computationally effective new tool for network analysis, tested against alternative Ricci–Ollivier flow coupled with spectral clustering.

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Multishifts on Hilbert spaces

Marija Stanić (University of Kragujevac, Kragujevac, Serbia)

Let D_+ be defined as $D_+ = \{z \in \mathbb{C} : |z| < 1, \mathrm{Im} z > 0\}$ and let Γ be a unit semicircle $\Gamma = \{z = \mathrm{e}^{\mathrm{i}\theta} : 0 \leq \theta \leq \pi\} = \partial D_+$. Let $w(z)$ be a weight function which is positive and integrable on the open interval $(-1, 1)$, though possibly singularity at the endpoints, and which can be extended to a function $w(z)$ holomorphic in the half disc D_+. Orthogonal polynomials on the semicircle with respect to the complex-valued inner product

$$(f,g) = \int_\Gamma f(z)g(z)w(z)(\mathrm{i}z)^{-1}\mathbb{D}z = \int_0^\pi f(\mathrm{e}^{\mathrm{i}\theta})g(\mathrm{e}^{\mathrm{i}\theta})w(\mathrm{e}^{\mathrm{i}\theta})\mathbb{D}\theta$$

was introduced by Gautschi and Milovanović in [2] (for $w(x) = 1$), where the certain basic properties were proved. Such orthogonality as well as the applications involving Gauss-Christoffel quadrature rules were further studied in [1] and [5]. Inspired by Laurie's paper [3], Milosavljević et al. in [4] introduced anti-Gaussian quadrature rules related to the orthogonality on the semicircle, presented some of their properties, and suggested a stable numerical method for their construction. In [6] we introduced the generalized averaged Gaussian quadrature rules on the semicircle. Two methods for their construction and some properties were derived. In addition, the accuracy of such quadrature rules and their applications were demonstrated through numerical examples.

In this lecture, we give a survey of the concept of orthogonality on the semicircle with respect to the complex-valued non-Hermitian inner product, and the corresponding Gaussian, anti-Gaussian, and generalized averaged Gaussian quadrature rules.

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On inequalities between different asymptotic characteristics of function classes

Vladimir Temlyakov (St. Petersburg State University and Steklov Mathematical Institute of RAS, Moscow)

We will discuss relations between the Kolmogorov widths, the entropy numbers, optimal errors of numerical integration, and other asymptotic characteristics. Both classical inequalities and new recently obtained inequalities will be presented. In addition, a number of open problems will be formulated.

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Theory and applications of tensor decompositions

Eugene Tyrtyshnikov (Marchuk Institute of Numerical Mathematics of RAS, Moscow)

It is commonly argued that efficient and reliable approximation algorithms for classical tensor decompositions are not available. We discuss some open theoretical questions that are believed to underly this opinion.

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State transfer with sufficient fidelity

Alexei Zhedanov (Renmin University of China, Beijing)

We present a new model of the state transfer of quantum information. This model can be considered as an interpolation between the "ideal"Krawtchouk chain and uniform Heisenberg chain. This model is more practical than the Krawtchouk chain and also it demonstrates sufficient fidelity of the quantum signal.