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BOOK OF ABSTRACTS

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Numerical Solution for 3D Nonlinear Differential Equation

B. Alkahtani

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In this poster, we consider the solution of the steady flow in a three-dimensional lid-driven cavity using numerical methods. The three-dimensional velocity-vorticity formulation, used by Davies & Carpenter (2001), is considered. The cubical lid-driven cavity problem is solved. The problem is discretized using the Chebyshev discretization in the y and z directions, and fourth-order finite differences are used for the discretization in the x direction. Newton linearization is used to linearize the problem and a direct solver is devoted to solve the problem. The problem has been coded in both the MATLAB and FORTRAN environments.

The lid-driven cavity problem is used typically to test new methods and codes. The lid-driven cavity can be introduced as a fluid contained in a cube domain with stationary rigid walls and a moving wall.

A Goodness-of-Fit Measure for Nonlinear Regression of Cell Viability Data

R. Anguelov

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Cell viability is a key endpoint in in vitro studies assessing the anticancer effects of growth inhibitors, commonly measured using assays such as the Crystal Violet and MTT assays. These experimental measurements often exhibit substantial variability, arising from differences in cell population properties, initial conditions, and inherent assay limitations – for example, each cell population (i.e., cells within a single well) is typically measured only once. To mitigate this variability, experiments are repeated multiple times, and subsequent curve or surface fitting is generally performed using only the mean values across replicates.

In this presentation, we propose a statistical framework that explicitly incorporates inter-experimental variability to derive a goodness-of-fit measure for regression models. This approach leverages the full structure of the data rather than relying solely on aggregated means. The proposed measure is particularly relevant for nonlinear and multivariate regression, where the traditional coefficient of determination (RI) has been shown to be inadequate for assessing model fit.

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On Fredholm integral equations with singular kernels

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We are considering Fredholm integral equations of the second kind:

$$u(x) = \lambda \int\limits_{\Omega} K(x,y)u(y)\,dy + f(x),$$

where Ω is a bounded region in $\mathbb{R}^n$ and the kernel K has singularity along the diagonal of Ω^2. We consider two types of singularities: power type singularity, $K(x,y) = \frac{L(x,y)}{\|x-y\|^\alpha}$; and logarithmic singularity, $K(x,y) = L(x,y)\log(\|x-y\|)$. In both cases L is a smooth function on Ω^2. We study Monte Carlo techniques for solving such integral equations. We discuss the obstacles encountered in such techniques due to the presence of singularities. We outline possible adaptations of the method in order to circumvent the difficulties. We also comment on theoretical aspects of convergence.

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Operator Learning for PDEs with Fixed Basis Representations

A. C. Aristotelous, A. Ur Rahman Akond

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We study operator learning for partial differential equations (PDEs) using fixed basis representations. In this setting, both the input function and the solution

are expressed in a finite-dimensional basis, and the problem reduces to learning a mapping between the corresponding coefficient vectors. This provides a structured formulation of operator learning in a reduced space.

We consider PDE model problems and examine different ways of training this mapping. A standard approach, as proposed in recent work by others, relies on reference solutions generated by a numerical solver and trains the network by matching these solutions. In contrast, we investigate whether training based directly on the governing equation by minimizing residuals in either strong or weak form, and without requiring reference solution data can serve as a viable alternative.

Avoiding the need for reference solutions is particularly relevant in higher-dimensional settings, where generating accurate solutions using numerical methods can be computationally expensive, and where even constructing representative sets of physically meaningful solutions for training can be challenging.

The focus of this work is to understand how these training formulations behave in the fixed basis setting. We examine their effect on accuracy, stability, and sensitivity to implementation choices such as activation functions, and related implementation choices.

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Transport safety – Methodology, Quantitative and Qualitative Assessment of the Link between Meteorological Conditions and Safety

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The road safety management methodology is based on a systematic and consistent approach, including the identification of high-risk areas, analysis of critical points, and application of safety assessment functions to determine the frequency and severity of accidents under baseline conditions. By prioritizing areas with heavy traffic and a high concentration of incidents, resource allocation is optimized and the likelihood of incorrect management decisions is minimized. The main aim of the methodology is to reduce the total number of road traffic accidents and limit severe consequences, including mortality. An essential element in this process is the consideration of climatic and meteorological factors as external determinants of risk. Rainfall, low temperatures, icing, fog, and extreme weather events affect the grip, visibility, and behavior of road users, which changes the probabilistic characteristics of accidents. Therefore, integrating climatic conditions into road safety assessment and management models increases their predictive value and contributes to more effective planning of preventive measures.

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Mathematical Modeling of Digital Documentation Adoption and Sustainability Indicators in Courier Services

S. Tranev, V. Traneva, V. Kolev and A. Baykin

Prof. Dr. Asen Zlatarov State University of Burgas, Bulgaria

The rapid digitalization of courier and logistics services implies new opportunities to improve operational efficiency and reduce environmental impact. This study presents a preliminary mathematical and statistical framework for analysis of the implementation of electronic documentation systems in courier services, based on operational data from VALDES 2017 Ltd. – franchise courier operator in Bulgaria – for the period November 2025 – April 2026 (average 10,000 shipments per month). It is important to note that the dataset presented is a simplified operational scenario designed to illustrate the potential impact of the adoption of electronic notes on administrative costs, rather than a real empirical record. Applied statistical methods include descriptive statistics, Pearson correlation analysis, and linear regression modeling. The results indicate a very strong negative correlation between the share of e-notes and operating costs, suggesting that digital document systems can serve as an effective tool within green logistics. Given the limited dataset and simplified assumptions of the model, the findings should be interpreted as preliminary results and not as final results.

Keywords: electronic documentation, courier services, green logistics, statistical analysis, regression model, sustainability, digital transformation

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Critical Examination of Depth-Sensing Indentation Techniques

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Depth-sensing indentation (DSI) techniques are widely used for estimating mechanical properties of small or thin samples of materials. DSI means that the load applied to a probe (indenter) and the displacement to the indenter are continuously monitored. If the maximum depth of indentation is below the micrometre scale, then the DSI techniques are referred to as depth-sensing nanoindentation. The DSI techniques are quite popular because they allow the researchers to estimate the reduced elastic (contact) modulus of contact pair of materials using the slopes of the unloading branches of the load-displacement curves using the so-called BASh (Bulychev-Alekhin-Shorshorov) formula [1] or its modifications, e.g. by a very popular method introduced by Oliver and Pharr (1992). It is argued that the common approaches to DSI experiments are based on the use of the non-adhesive Hertz contact theory, while it is important to consider molecular adhesion between the probe and the tested materials because the slopes of the load - displacement curves may considerably differ from the slopes derived using the non-adhesive contact theory [2]. Then it is discussed the BG method based on DSI of spherical indenters [3, 4]. It is shown that the BG method is an effective and robust method of identification of elastic and adhesive properties of materials and structures (e.g. coatings) from DSI tests.

References

[1] F. M. Borodich (2014) The Hertz-type and adhesive contact problems for depth-sensing indentation, *Advances in Applied Mechanics*, 47, 225-366.
[2] F. M. Borodich, B.A. Galanov. (2022) Adhesive depth-sensing indentation tests: Slopes of the force - displacement curves, *Mechanics Research Communications* **126**, 104008.
[3] F. M. Borodich, B.A. Galanov (2008) Non-direct estimations of adhesive and elastic properties of materials by depth-sensing indentation, *Proc. R. Soc. Ser. A* **464**, 2759–2776.
[4] N.V. Perepelkin, A.E. Kovalev, S.N. Gorb, F.M. Borodich (2019) Estimation of the elastic modulus and the work of adhesion of soft materials using the extended Borodich-Galanov (BG) method and depth sensing indentation, *Mechanics of Materials* **129**, 198–213.

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Critical Nonlinear Elliptic and Hyperbolic PDE Systems

Yu. Bozhkov

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We review the symmetry-based approach to determining critical exponents for scalar PDEs and systems. Additionally, we derive new critical curves for semilinear elliptic and hyperbolic PDE systems involving polyharmonic operators.

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Classifications on Soliton Solutions of KP Type Systems

Chuanzhong Li

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In this talk, we will give a classification of the regular soliton solutions of the KP hierarchy, referred to as the KP solitons, under the Gel'fand-Dickey reductions in terms of the permutation of the symmetric group. As an example, we show that the regular soliton solutions of the (good) Boussinesq equation as the 3-reduction can have at most one resonant soliton. In particular, we show that the non-crossing permutation gives the regularity condition for the soliton solutions. Meanwhile the classification on singular soliton solutions of the Boussinesq equation is also interesting.

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On the Analysis of the Phase Spectrum of a Two-Frequency Signal

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The results of an analysis of the spectrum of a signal formed by the beating of two monochromatic oscillations are presented. Using the analytic signal model, it is shown that the resulting signal can be represented as a linear combination of a tonally modulated AM oscillation and a narrowband FM oscillation. The relationship between the phase spectrum and the instantaneous frequency of the signal is examined.

The calculation of the instantaneous frequency demonstrates that the instantaneous frequency function differs from the linear one characteristic of AM oscillations. Thus, the information content of the two-frequency oscillation is determined primarily by the FM component, whose spectral width is at least twice that of the AM component.

It is shown that the analytic model of the two-frequency signal is described by a trochoid-type function. It is noted that the obtained results may be used for processing biomedical signals such as EEG.

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Image Analysis and Reconstruction of a Moving Target

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SAR imaging techniques typically operate using one method of scattering approximation, are still highly susceptible to noise, and primarily focus on stationary objects. The purpose of the project is to apply microlocal analysis and Fourier Integral operator theory to develop Born and Kirchhoff Approximations to create two algorithms to run in parallel. The goal is to use information from both reconstructions to see how accuracy in identification can improve on stationary objects

and moving objects. The tools to be used will be a Raspberry Pi Computer in conjunction with a Desktop Computer/Laptop to create a system that collects SAR data and then processes the data to reconstruct the image with the desired algorithms. The Raspberry Pi 4 computer will be adapted into a home-scale SAR Radar system using SDR antennas, a rail system, and antennas to transmit and receive signals. The data will be streamed onto the desktop/laptop in order to process the data using open-source models available in Python (such as RadarSimPy) and the two algorithms developed to aid in the reconstruction. As images are identified, a database will be built, so it can be utilized as a lookup table when trying to identify objects. It is expected that the more data available, the better an object and its trajectory can be predicted and reconstructed.

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Casimir Forces in the One-Dimensional Three-State Potts Model

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We investigate the Casimir force in the one-dimensional three-state Potts model in the presence of an external field coupled to a single spin state. Using an exact transfer-matrix formulation, we derive closed-form expressions for the eigenvalues and construct a scaled transfer matrix that isolates the finite-size contribution to the free energy. We compute the Casimir force for periodic, antiperiodic, and Dirichlet boundary conditions and show that each boundary condition probes a distinct symmetry sector of the model. Periodic boundaries lead to a small saturation plateau, antiperiodic boundaries produce a characteristic sign change associated with an eigenvalue crossing, and Dirichlet boundaries yield a rapidly decaying force dominated by the largest eigenvalue. These results provide a complete and analytically controlled characterisation of finite-size effects in the Potts chain and illustrate how boundary constraints shape the qualitative behaviour of the Casimir force.

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Approximate Solution of Biharmonic Problems in Multiply Connected Non-smooth Domains

V. Didenko

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The stability of popular boundary element methods for biharmonic problems in 2D multiply connected piecewise-smooth domains is studied. It is shown that the methods under consideration are stable if and only if certain auxiliary operators are invertible.

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On $\sigma\psi\phi$-cubic κ-tuples and Their Generalizations

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The paper introduces a new class of arithmetic objects called $\sigma\psi\phi$-cubic κ-tuples, defined through polynomial identities involving the classical arithmetic functions $\sigma(n)$, $\psi(n)$, and $\phi(n)$. The study is motivated by modern extensions of the notions of perfect and amicable numbers, as well as by current research on Diophantine equations associated with arithmetic functions. We undertake a partial analysis of $\sigma\psi\phi$-cubic pairs and provide explicit constructions of families of $\sigma\psi\phi$-cubic triples and quadruples. The work further develops natural generalizations, including $\sigma^2\psi\phi$-quartic and $\sigma^3\psi\phi$-quintic tuples, for which questions concerning infinitude naturally arise. These results extend and refine earlier works on σ-quadratic κ-tuples, ψ-amicable numbers, ψ-quadratic κ-tuples, and $\sigma\psi$-quadratic κ-tuples.

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Towards a General Theory of GPS Inter-satellite Communications between Moving Satellites on Arbitrary Space Trajectories Accounting for General Relativity Effects

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In previous publications [1,2,3,4] it has been shown that **1.** It is possible to calculate (in terms of zero and higher order elliptic integrals) the propagation time of a signal, emitted by a satellite, moving along a plane (or space-determined) Kepler orbit. **2.** By means of a method of intersecting null cones, together with the algebraic equation for the differential of the Euclidean distance, the propagation time was found for the case, when the signal is intercepted by a second satellite. In both cases, the curving of the signal trajectory has been accounted due to the action of the gravitational field. Since the real motion of satellites is highly perturbed and beyond the idealized approximation of Kepler orbits, the present report, based on [5], has the purpose to generalize the above approach for satellites, exchanging signals and moving along arbitrary space trajectories. Previously in [1,3,4], the important physical notions of "space-time distance" (negative, equal to zero or positive), "condition for inter-satellite communications" and "geodesic distance" R (only positive and greater than the Euclidean distance, since is related to the real distance, at which the signal is propagating) have been introduced. In [5] and also in this report it is shown that these notions can be introduced also for the case of general motion of the satellites, and more importantly, they have the same physical meaning. The s.c. "ranging equation" will be briefly discussed, introduced in A. Einstein's known monograph [6]. In the partial cases and in the general case, the equation establishes the relation $c(T_2 - T_1) - R = 0$ between the propagation times, the Euclidean distance and the geodesic distance R. Such a general theory of inter-satellite communications is the first step towards constructing a modern theory for optimal propagation (i.e. for the least time) of signals in a set of satellites in the near-Earth space, thus achieving high-rate data transfer [7] by means of laser communications between the satellites and relaying data around the globe with the purpose of early warning/tracking of missile launching [8].

References

[1] B. Dimitrov, Two null gravitational cones in the theory of GPS-intersatellite communications between two moving satellites. I. Physical and mathematical theory of the space-time interval and the geodesic distance on intersecting null cones. `https://arxiv.org/abs/1712.01101v3`, 162 p. (2017).

[2] B. Dimitrov, New Applications of Elliptic Functions and Integrals in GPS Inter-Satellite Communications with Account of General Relativity Theory, review article, special volume "Advances in Elliptic Equations and Their Applications" of

the MDPI journal *Mathematics* **13**(8), 1286 (67 pages) (2025), online at https://www.mdpi.com/2227-7390/13/8/1286.
[3] B. Dimitrov, Elliptic Integrals for Calculation of the Propagation Time of a Signal, Emitted and Received by Satellites on One Orbit. *AIP Conf. Proc.* **2522**, 090004, 13p (2022) https://web.archive.org/web/20220928062950id_/https://aip.scitation.org/doi/pdf/10.1063/5.0101261
[4] B.G. Dimitrov, Mathematical and Physical Modeling of Communications Between GPS/GNSS Satellites With Account of the General Relativity Effects . SES 2025 Twenty-first International Scientific Conference *Space, Ecology, Safety* 21–25 October 2025, Sofia, Bulgaria, Space Research and Technology Institute, Bulgarian Academy of Sciences, 2025; http://space.bas.bg/SES/archive/SES
[5] B. Dimitrov, Space-Time Distance, Geodesic Distance and Ranging Equation on Intersecting Null Cones in the Algebraic Geometry Theory of GPS Inter-Satellite Communications, to be submitted to the MDPI journal *Mathematics* (2026).
[6] A. Einstein, *The Meaning of Relativity. The Stafford Little Lectures of Princeton University, May 1921*; (Princeton University Press: Princeton, New Jersey, USA, 1954).
[7] Jan 9, 2025, U.S. military satellites achieve first cross vendor laser communications link, https://spacenews.com/u-s-military-satellites-achieve-first-cross-vendor-laser-communications-link/.
[8] Jan 10, 2025 Small Satellite Architectures Get New Boosts From SDA, NRO https://www.airandspaceforces.com/sda-nro-small-satellite-architectures/.

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Kink-Type Solutions and Streak-Like Structures in Turbulent Channel Flow Using the Alexeev Hydrodynamic Framework

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An analytical framework for turbulent channel flow is developed based on the Alexeev hydrodynamic equations, focusing on the coupled behavior of streamwise and transverse velocity components [1]. The mean streamwise velocity is represented as a superposition of a laminar (parabolic) component and a nonlinear turbulent contribution, yielding velocity profiles that agree with experimental data from channel and pipe flows over a wide range of Reynolds numbers, $3 \times 10^3 \leq Re \leq$

3.5×10^7, with deviations of approximately 1% at moderate Reynolds numbers and up to 3% at the highest Reynolds numbers[2,3,4,5].

The transverse velocity component is analyzed using a simplified form of the governing equations, leading to analytical expressions that capture its dominant spatial structure. The coupling between transverse velocity and streamwise momentum is then examined, revealing that the streamwise turbulent component admits a family of kink-type solutions.

These solutions exhibit localized monotonic transitions separating regions of nearly uniform velocity and are interpreted as analytical representations of streamwise streaks. The model predicts characteristic streak properties, including spacing, thickness, intensity, and streamwise extent, which are shown to be consistent in order of magnitude with experimental observations of near-wall streaks.

The results provide a unified analytical description of mean velocity profiles, secondary flows, and streak formation in wall-bounded turbulence, and suggest a mechanism linking transverse velocity fluctuations to the emergence of coherent streamwise structures.

References

[1] B.V. Alexeev (1994) The generalized Boltzmann equation, generalized hydrodynamic equations and their applications, *Phil. Trans. Roy. Soc. London, A* **349**, 417–443.
[2] A. Fedoseyev (2023) Approximate analytical solution for turbulent flow in channel, *J. Phys.: Conf. Ser.* **2675** 012011.
[3] A. Fedoseyev (2026) "Controlling turbulent boundary layer flow through the transverse velocity component, Chapter in book: Boundary Layer Flows – Control Techniques and Technological Applications", ISBN 978-1-83634-298-4, Ed. Zambri Harum (in print), `https://www.intechopen.com/`.
[4] A. Fedoseyev (2024) Analytical solution for transverse velocity of turbulent flow in channel, *J. Phys.: Conf. Ser.* **2910**, 012013.
[5] A. Fedoseyev (2025) Improved analytical solution for turbulent flow in channel and circular pipe, *J. Phys.: Conf. Ser.* **3145**, 012011.

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Alexeev Hydrodynamic Equations for Turbulent Flows: Analytical and Numerical Solutions with Experimental Validation

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Understanding turbulent flows remains a central problem in fluid dynamics, particularly regarding near-wall structures and scaling behavior. In this work, we investigate analytical and numerical solutions for laminar and turbulent flows using both the classical Navier-Stokes (NS) equations and the Alexeev hydrodynamic equations (AHE), and compare the results with turbulent models, DNS data, and experimental measurements. The AHE are derived from the Generalized Boltzmann Equation, which accounts for non-local effects and finite collision-time dynamics [1].

Analytical solutions are obtained for stationary states corresponding to mean flow quantities, as well as transient solutions. The AHE solutions are validated against experimental and numerical results and compared with NS predictions across multiple studies spanning Reynolds numbers from $3 \times 10E3$ to $3.5 \times 10E7$. The AHE-based solutions show consistently improved agreement with experimental velocity profiles over this wide range, while the stationary NS solutions exhibit systematic deviations.

The analysis reveals a new similarity parameter associated with the boundary-layer thickness, providing additional structure to turbulent scaling. A reduced formulation for the transverse velocity component yields analytical solutions consistent with experimental observations of secondary flows. The coupling between the transverse velocity and streamwise momentum is examined, revealing that the streamwise turbulent component admits a family of kink-type solutions, establishing a mechanistic link between transverse velocity dynamics and the formation of coherent near-wall structures.

Another important application of the AHE involves hypersonic flows at high altitude, demonstrating that the approach remains valid even for rarefied flows where traditional continuum assumptions break down. Results will be presented for a wide range of Mach numbers (1.5-50), Reynolds number (1000-30,000) and Knudsen numbers (0.01-15), with experimental and DSMC comparisons.

Overall, the results offer a unified framework for mean velocity profiles of laminar and turbulent flows, secondary flows, and streak formation in turbulent channel flow, and suggest that non-local hydrodynamic effects play an important role in wall-bounded turbulence [2–11].

References

[1] B.V. Alexeev (1994) The generalized Boltzmann equation, generalized hydrodynamic equations and their applications. *Phil. Trans. Roy. Soc.* London, A. 349, 417–

443.
[2] A. Fedoseyev (2026) "Controlling Turbulent Boundary Layer Flow through the Transverse Velocity Component," Chapter in book: Boundary Layer Flows - Control Techniques and Technological Applications, ISBN 978-1-83634-298-4, Ed. Zambri Harum (in print),`https://www.intechopen.com/`.
[3] A. Fedoseyev (2025) Improved Analytical Solution for Turbulent Flow in Channel and Circular Pipe, *J. Phys.: Conf. Ser.* **3145**, 012011.
[4] A. Fedoseyev (2024) Analytical Solution for Transverse Velocity of Turbulent Flow in Channel, *J. Phys.: Conf. Ser.* **2910**, 012013.
[5] A. Fedoseyev (2024) Modeling of Turbulent Flow over 2D Backward-Facing Step Using Generalized Hydrodynamic Equations, L. Franco, ed. ICCS 2024, Springer; *LNCS* **14838**, p. 63–69.
[6] A. Fedoseyev (2023) Approximate Analytical Solution for Turbulent Flow in Channel, *J. Phys.: Conf. Ser.* **2675** 012011.
[7] A. Fedoseyev, B.V. Alexeev (2012) Generalized hydrodynamic equations for viscous flows-simulation versus experimental data,in *AMiTaNS'12*, American Institute of Physics *AIP CP* **1487**, pp.241–247 (2012).
[8] A. Fedoseyev, V. Griaznov, J. Ouazzani (2023) Simulation of rarefied hypersonic gas flow and comparison with experimental data I, American Institute of Physics Conference Proceedings *AIP CP* **2953**.
[9] A. Fedoseyev, V. Griaznov (2021) Simulation of Rarefied Hypersonic Gas Flow and Comparison with Experimental Data, American Institute of Physics Conference Proceedings vol. 2522, paper 100003.
[10] A. Fedoseyev (2020) Finite element method stabilization for supersonic flows with flux correction transport method, American Institute of Physics Conference Proceedings vol. 2302, paper 120003.
[11] A.I. Fedoseyev, B.V. Alexeev, Mathematical model for viscous incompressible fluid flow using Alexeev equations and comparison with experimental data, in: S.K. Dey, G. Ziebarth, eds.. *Proc. Advances in Scientific Computing Modelling (Special Proc. IMACS'98)*, Alicante, Spain: IMACS; 1998. p.158–163.

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Cauchy Problems Describing Pseudospherical Surfaces: The Camassa-Holm and Degasperis-Procesi Cases

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Federal University of São Carlos, Brazil

It is well known that solutions of certain integrable equations can define abstract surfaces with negative and constant Gaussian curvature, commonly referred to as pseudospherical surfaces. Many of these equations are viewed as evolution equations and have been extensively studied, particularly regarding the existence and uniqueness of solutions. In this talk, we will explore the connections between Cauchy problems and pseudospherical surfaces, with a particular focus on the Camassa-Holm and Degasperis-Procesi equations.

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Statistical Modeling of Energy Yield from a Manually Adjusted Photovoltaic System: A Case Study from Shkorpilovtsi, Bulgaria

I. Nikolaev, S. Georgiev

Angel Kanchev University of Ruse, Bulgaria

This work investigates the extent to which a simple manual orientation adjustment can improve the energy yield of a small photovoltaic system installed in the area of Shkorpilovtsi, Bulgaria. The system consists of two photovoltaic modules of 230 Wp each, operated either in stationary mode or with manual adjustment in five predefined positions during the day, according to the apparent solar position. The recorded data include time-resolved cumulative energy and instantaneous electrical power for selected cloud-free days. The analysis is based on paired comparisons of comparable day pairs, in which one day corresponds to stationary operation and the neighboring cloud-free day to manual adjustment. The primary response variable is the final daily cumulative energy, while the intraday power profiles are used to assess the temporal structure of production gains. To quantify the effect of the operating regime, we combine descriptive comparison, paired statistical testing, and regression modeling with time-of-day and adjustment-mode covariates. The proposed statistical framework can be extended to longer monitoring periods, additional meteorological covariates, and predictive models of photovoltaic output.

The study contributes to applied statistical modeling of renewable-energy data and provides practical evidence for small-scale photovoltaic optimization under real operating conditions.

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Time Reparametrization Invariance and the Hubble Tension

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The discrepancy between the value of the Hubble constant H0 obtained by local measurements and the one deduced from the Cosmic Microwave Background (CMB) observations has been a persistent issue for modern cosmology and is known as the Hubble Tension. Without a strong guiding principle the space of possibility to explore is limitless. As such, it has been an arena of fruitless explorations of exotic physics using models with new particles and fields. A recent 2026 paper by Courbin and Maeder have demonstrated that the tension can be resolved with the Scale Invariant Vacuum (SIV) paradigm. In this paper, a mathematically equivalent but physically different idea about the time Re-parameterization Invariant Scaling Symmetry (RISS) is utilized to build a model that could address the Hubble Tension without the need of new particles or fields. The time dependent units rescaling $(dt, dr) \rightarrow \lambda(t)(dt, dr)$ is almost exact within the modern treatment of the CMB phenomenon. While the corresponding equivalent symmetry, based on the Weyl transformation $(a, N) \rightarrow (a, N)\lambda(t)$ imposes augmentation of the Friedmann-Lemaotre-Robertson-Walker (FLRW) equations for cosmology as done in the SIV paradigm. The Hubble Tension is then recognized to be due to difference in the unit of time during the decoupling era and the current era since the corresponding gravitational potentials are different.

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Fostering Student Engagement and Experiential Learning at the STEM Center and Center for Cellular and Biomolecular Machines, UC Merced

P. Gueorguieva and C. Kouadio

University of California Merced, USA

The STEM Center and the Center for Cellular and Biomolecular Machines (CCBM) at the University of California, Merced, are dedicated to guiding and supporting undergraduate students as they persist and reach their full academic potential. Our presentation highlights the broader impact of sciences, with a focus on student engagement and experiential learning. We discuss key student support initiatives led by the STEM Center and CCBM, including: (1) the development and assessment of CCBM undergraduate research programs; (2) contributions to extracurricular activities within the local K-12 community; (3) personalized academic advising; and (4) tutoring services. We present the core components of these programs and outline their positive impacts on student participants. Additionally, we describe our approaches to measurable assessment and data-driven program evaluation.

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Assessment of Systematic Risk in Investment Portfolios Using Stochastic Power Methods

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This study investigates the application of stochastic power methods to quantitatively assess market risk in investment portfolios through the spectral characteristics of return correlation matrices. The main aim is to estimate the largest eigenvalue of the correlation matrix, regarded as an indicator of the existence and strength of a dominant common market factor. In this context, the largest eigenvalue and its corresponding fraction of variance explained (FVE) are used as tools to measure the level of systematic risk and to explore the limitations of diversification within an investment portfolio. This approach links the theoretical analysis of stochastic power methods with their practical application in financial modelling and risk management. The methodological framework relies on almost optimal Power Monte Carlo (PMC) and Power Quasi-Monte Carlo (PQMC) algorithms to numerically

estimate the dominant eigenvalue [1]. In the PQMC approach, variants using scrambled Halton and Sobol sequences are examined. The empirical analysis uses financial data obtained from Portfolio Visualizer and Yahoo Finance via the yFinance library. Two correlation matrices are constructed: the first based on monthly returns of 32 global assets from 2007 to 2024, and the second on monthly returns of companies in the SP 500 index from 2021 to 2025. The numerical results show that the proposed algorithms achieve high accuracy and stable convergence in estimating the dominant eigenvalue. The findings further suggest that these methods offer timely and informative quantitative indicators for assessing systematic market risk, thus supporting their use in portfolio analysis and risk management practice.

References

[1] S.-M. Gurova, T. Gurov, A. Karaivanova (2025) On the Stochastic Power Algorithms for Estimating the Maximum Eigenvalue of Symmetric Matrices, *Contemporary Mathematics* **6**(5), `https://doi.org/10.37256/cm.6520257781`.

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Stochastic Extinction and Threshold Dynamics in a Markovian Predator-Prey SEIRS Epidemic Model

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Institute of Information and Communication Technologies, Bulgarian Academy of Sciences

This work proposes a stochastic extension of a predator-prey eco-epidemiological model with SEIRS infection dynamics in the prey population. The prey is divided into susceptible, exposed, infected, and recovered classes, while the predator population interacts with all prey classes through class-dependent predation rates. The model is formulated as a continuous-time Markov chain (CTMC) on the state space Z^5, where birth, infection, incubation, recovery, loss of immunity, mortality, migration, and predation are described by transition intensities.

The aim is to study how demographic stochasticity affects disease extinction and persistence. Positivity of the Markov process, non-explosion, and absorption of the disease-free set are established. A stochastic basic reproduction number is derived by using a two-type branching process approximation near the disease-free equilibrium. It is shown that if this threshold is less than or equal to one, the infection becomes extinct almost surely in the initial epidemic phase, while values greater than one imply a positive probability of outbreak. The connection between the Markov chain model and its deterministic mean-field limit is also discussed.

Numerical experiments are performed using Gillespie's stochastic simulation algorithm. The simulations compare deterministic and stochastic trajectories for different infection, predation and immunity-loss parameters. The results show that stochastic effects may lead to disease extinction even when the deterministic model predicts persistence.

Keywords: predator-prey model, SEIRS epidemic, continuous-time Markov chain, stochastic extinction, basic reproduction number, Gillespie algorithm

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Convexification of Kolmogorov-Arnold Net (KAN): Special Cases

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A KAN layer implements the Kolmogorov-Arnold representation, and training minimizes an empirical loss $L(\theta)$ over the spline coefficients, weights, and grid points. The question of "convexification" is: can we reformulate this so the optimization landscape is convex (or equivalently, find a tight convex relaxation)? For an arbitrary multi-layer KAN, convexification in closed form is impossible. However, there are at least four regimes where the problem becomes (provably) convex or admits a tight convex relaxation. We will focus our discussion of such regimes, in particular, the single-layer KAN with fixed grid and convex loss, two-layer KAN via lifting (Pilanci-Ergen style), the infinite-width/kernel limit, and the convex Kolmogorov-Arnold representations of specific function classes.

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Heterogeneous Causal Effects of Donor Hormonal Resuscitation on Heart-Transplant Survival: A Doubly Robust IPW–Cox Framework with Phenotype-Stratified Treatment Effects

R. Haynatzki, G. Haynatzki, J. Windle

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Donor hormonal resuscitation is incorporated into the OPTN Critical Pathway for organ donors, but the available randomized evidence remains fragmented and the conditional causal effect of the joint cocktail on heart-transplant recipient survival is unresolved. This study aims to rigorously estimate this causal effect and identify heterogeneous treatment responses across donor phenotypes. We propose a doubly robust causal-inference pipeline utilizing adult and pediatric heart-transplant records from the OPTN/UNOS STAR file, defining the exposure as the administration of at least two of the four primary hormonal components. To adjust for measured confounding, propensity scores will be estimated using cross-fitted, isotonically recalibrated XGBoost classifiers. We will subsequently apply a doubly robust inverse-probability-weighted Cox proportional-hazards model to evaluate the overall survival benefit. Rather than relying on arbitrary pre-specified subgroups, we will deploy unsupervised K-Means clustering on the standardized confounder matrix to surface natural clinical phenotypes and compute stratum-specific hazard ratios. Finally, a Weibull accelerated failure time sensitivity analysis will be utilized to test the proportional-hazards assumption under a distinct parametric structure. This methodological framework is designed to provide data-driven evidence on whether donor hormonal resuscitation should be applied uniformly across the donor pool or targeted toward specific, physiologically vulnerable donor profiles.

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Existence and Multiplicity Results for Fractional Schrödinger Equations with Critical Growth

Huilin Lv

Wenzhou University, China

The fractional Schrödinger equation has attracted significant attention in nonlinear analysis due to its theoretical interest and applications. In this talk, we

investigate the existence and multiplicity of solutions for fractional Schrödinger equations with combined nonlinearities. We demonstrate how variational methods and topological arguments are employed to overcome the compactness issues arising from the critical growth.

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Maintaining Maximum Profit via Profit-Maximizing Zones under Fixed and Variable Pricing

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Sustaining profitability requires more than identifying a single profit-maximising output level. It also requires an operational range that remains economically justified under routine managerial and process constraints. This paper proposes a numerical framework that estimates an organisation-specific total cost function, computes the profit-maximising output under two pricing regimes - fixed price (price-taking) and variable price driven by a demand relation and constructs near-optimal profit zones defined as output intervals that achieve at least a chosen proportion of the maximum attainable profit. The framework combines marginal analysis, where profit is maximised at the output level where marginal revenue equals marginal cost, with robust one-dimensional root-finding and line-search methods that can be implemented in numerical environment.

A synthetic case study (EUR millions; output in thousand units) demonstrates the workflow and shows that near-optimal zones provide actionable decision bands beyond point estimates.

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Vortices Interacting with Long Surface Water Waves

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Simion Stoilow Institute of Mathematics of the Romanian Academy, Bucharest, Romania

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Institute of Mathematics and Informatics, Bulgarian Academy of Sciences, Sofia, Bulgaria

Point vortex interacting with long surface waves is described by a perturbed KdV equation [1]. The investigation of this model shows that the solitary waves on the surface are not destroyed by the interaction with the vortex, and, as a matter of fact, the solitary waves remain practically unaffected for a significant range of the vortex strength. The numerical and analytical studies are presented and analysed. As a result, a further simplification of the model is proposed, where the vortex motion under solitons propagating on the surface is determined from a system of decoupled ordinary differential equations.

References

[1] D. Ionescu-Kruse, R. Ivanov, M. Todorov (2026) Point Vortex Dynamics Influenced by the Surface Motion, *J. Nonlinear Sci.* **36**, `https://doi.org/10.1007/s00332- 025-10222-y`.

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Error Estimates of Some Linearized Schemes for the Logarithmic Schrodinger Equation

Jingye Yan

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The logarithmic Schrödinger equation (LogSE) has a logarithmic nonlinearity that is not differentiable at the origin. Compared with its counterpart with a regular nonlinear term, it possesses richer and unusual dynamics, though the low

regularity of the nonlinearity brings about significant challenges in both analysis and computation. Among very limited numerical studies, the semi-implicit regularized method via regularizing as to overcome the blowup of at has been investigated recently in the literature. With the understanding of $f(0) = 0$, we analyze the non-regularized first-order implicit-explicit scheme for the LogSE. We introduce some new tools for the error analysis that include the characterization of the Holder continuity of the logarithmic term, and a nonlinear Gronwall's inequality. We provide ample numerical results to demonstrate the expected convergence. We position this work as the first to study the direct linearized scheme for the LogSE as far as we can tell.

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AI for BMG

Jingli Ren

Zhengzhou University, China

This report explores the application of artificial intelligence in the discovery and optimization of bulk metallic glasses (BMGs). Traditional BMG development is hindered by vast compositional spaces and complex processing–property relationships. AI methods enable rapid prediction of glass-forming ability and mechanical properties, significantly accelerating material design. Case studies show successful AI-driven discovery of novel BMGs with enhanced performance.

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Posedness and Infinite Regularity of Invariant Measures for a Stochastic Modified Swift-Hohenberg Equation

Jintao Wang

Wenzhou University, China

We consider a 2D stochastic modified Swift-Hohenberg equations with multiplicative noise and periodic boundary. First, we establish the existence of local and global martingale and pathwise solutions in the regular Sobolev space H^{2m} for each $m \geqslant 1$. Associated with the unique global pathwise solution, we obtain a

Markovian transition semigroup. Then, we show the existence of invariant measures and ergodic invariant measures for this Markovian semigroup on H^{2m}. At last, we improve the regularity of the obtained invariant measures to $H^{2(m+1)}$. With appropriate conditions on the diffusion coefficient, we can deduce the infinite regularity of the invariant measures, which was conjectured by Glatt-Holtz.

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New Dynamical Phenomena for the Hamilton-Jacobi Equation

Kaizhi Wang

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The weak KAM theorem tells us that the dynamical behavior of the semiflow generated by the Hamilton-Jacobi equation, which originates from classical mechanics, is simple. However, the dynamical behavior of the semiflow generated by the contact Hamilton-Jacobi equation, which has profound backgrounds in fields such as thermodynamics, is completely different. This talk will cover topics related to the (in)stability, the existence and multiplicity of periodic and quasi-periodic solutions, as well as chaotic phenomena, concerning the contact Hamilton-Jacobi equation.

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Methods and Algorithms for Assessing Energy Usage by Hybrid Quantum-classical Algorithms

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Although there has been substantial progress in the development of quantum computing devices, they still suffer from limitations like high noise and insufficient number of qubits. Even under the assumption of ideal execution of quantum gates, algorithms like QAOA may include a substantial classical part, for example in

trying local improvement to the obtained solutions. As these types of algorithms are computationally intensive, the question of their energy use becomes important in practice. In this work, we develop and test methods and algorithms that attempt to attribute the overall energy usage of an instance of a particular hybrid quantum-classical algorithm to the various individual hardware components of an HPC system like processors, memory, GPUs, interconnects.

Our benchmark case is an application of QAOA to the MaxCut problem, where we have a balance between the simulation phase, which can in principle be replaced with execution on a hardware quantum device, and the local improvement phase, where the HPC system capabilities are used in order to improve the final solution. We study extensively the effects of parameters of both the problem and the solver on the energy use distribution. Our methods and algorithms are intended to help guide the development and use of hybrid quantum classical algorithms with improved energy efficiency.

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A Single-View Occupancy Network for Implicit 3D Surface Reconstruction from RGB Images

Y. Vasileva, H. Kalinov, M. Kolev, S. Stoilova, I.Nikolova

University of Architecture, Civil Engineering and Geodesy, 1046 Sofia, Bulgaria

Reconstructing a complete three-dimensional shape from a single photograph is an ill-posed but highly practical problem, with applications spanning rapid prototyping, digital archiving, robotics, and 3D printing. We present a single-view 3D reconstruction framework based on a deep implicit occupancy representation, in which a continuous occupancy field is learned directly from RGB images rather than an explicit voxel grid, point cloud, or mesh. An ImageNet-pretrained ResNet-18 encoder maps an input image to a compact 256-dimensional latent code, which conditions a fully connected decoder that predicts the inside/outside occupancy probability of any queried spatial coordinate. This formulation decouples shape resolution from network size, allowing the surface to be sampled at arbitrary fidelity at inference time. The model is trained end-to-end on the ShapeNet dataset across thirteen object categories using a binary cross-entropy objective, with query points drawn from a mixture of near-surface and uniformly sampled locations to balance boundary precision and global coverage. At inference, the learned field is evaluated on a dense regular grid and converted into a watertight triangular mesh via the marching-cubes algorithm, yielding a printable surface (STL) from a single image. We describe the complete pipeline—data preparation and occupancy sampling, encoder–decoder architecture, training procedure, and mesh extraction—and discuss

the trade-offs governing grid resolution, occupancy threshold, and reconstruction quality. The result is a lightweight, modular, and reproducible system that demonstrates how implicit neural representations make single-view 3D scanning accessible with modest computational resources.

Keywords: single-view 3D reconstruction; occupancy networks; implicit neural representations; ShapeNet; ResNet encoder; marching cubes; deep learning; mesh generation

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Quantile-Regression Analysis of Blood-Pressure Determinants Across the Conditional Distribution

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Blood pressure is shaped by metabolic, anthropometric, demographic, and lifestyle factors, yet most population models target only the conditional mean and therefore obscure how these determinants act at the hypertensive tail of the distribution. We address this with quantile regression, estimating covariate effects on systolic and diastolic blood pressure across a grid of conditional quantiles ($t = 0.05 - 0.95$) using the National Health and Nutrition Examination Survey (NHANES). Linear and additive, spline-based quantile specifications are fitted with survey weights; quantile-process inference and bootstrap confidence bands quantify how each effect varies along the distribution, and formal tests of slope equality across quantiles identify genuinely heterogeneous determinants. We expect adiposity and glycemic markers to exert markedly larger effects in the upper quantiles than at the median, while selected protective factors attenuate at the tail—a pattern invisible to mean regression. The framework yields distribution-aware, interpretable risk descriptions on fully public data and provides a methodological complement to mean-based cardiometabolic models. All analysis code is released as supplementary material.

Keywords: quantile regression; blood pressure; NHANES; conditional distribution; heterogeneous effects; hypertension; survey-weighted estimation; population health

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Precise Calculations of Gravity Anomalies from the Geometric Height for Autonomous Air Navigation

A. Madzharov

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Modern aviation systems have an extended altitude-speed range and place increased demands on gravity field models used in the equations of autonomous navigation systems. On-board computers can perform high-precision calculations in real time. It is no longer a problem to perform analytical calculations in floating-point algorithms with at least 12 significant mantissas, as well as integer ones in SoC Command and control systems (C2) for UAV platforms. These technological hardware capabilities must be used with adequate mathematical models for real-time recalculation of the gravity field. This project examines the analytical recalculation of the force of gravity in flight at low altitudes, high, even hyper-high speeds, with exceptional Flight Distance/Range and Duration of flight. Analytical gravity and inertial corrections have been achieved, valid for high-precision autonomous inertial algorithms taking into account small fourth-degree numbers relative to the eccentricity of a reference ellipsoid and comparable to the differences between historically used Earth Geopotential Models.

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Application of Kummer's Equation for Flight Between Two Geodesic Orthodromes in a Coordinated Turn

A. Madzharov

Institute of Robotics, Bulgarian Academy of Sciences, Sofia, Bulgaria

A flight between two adjacent orthodromes is considered, performed under the condition of a coordinated turn and with pre-calculated linear lead of the turn, initial, final and intermediate orthodromes angles. The motion of an aircraft is modelled as a 6-DOF (Six Degrees of Freedom) rigid body material model. Under these conditions, the passing of a new orthodrome is associated with a momentary jump in lateral acceleration. To avoid this effect, the coordinated turn is described with the clothoid. A clothoid is a three-dimensional mathematical curve located on the surface of an ellipsoid whose geodesic curvature varies linearly with the length of the arc or distance travelled. The system of differential equations for the motion of an aircraft in a coordinated turn when passing another orthodrome

is derived as a special case of Kummer's Confluent Hypergeometric Differential Equation. A dependence of the azimuth angle on the distance traveled is introduced. A differential equation of orthodrome is derived from the gyro-semicompass course, read relative to the instrumental gyroscopic direction. A specific example of transformation of variables and derivation of the Kummer equation is given. Boundary conditions for the gyroscopic course during the transition between two adjacent orthodromes are defined. The result of applying Kummer's functions allows for accurate analytical projection of the turn trajectory directly onto the surface of the WGS 84 ellipsoid, avoiding errors from cartographic projections. An optimization of the autopilot and Flight Management System (FMS) has been made, solving the problem of real-time Waypoint sequencing, allowing the FMS to issue continuous pitch commands as the aircraft traverses the new geodetic trajectory.

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Topological Games Related to Selective Versions of Separability

S. Ozcag, H. Saraf

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In this talk we focus on the game-theoretic approach to selective versions of separability in particular M-separability and R-separability in bitopological spaces. We introduce infinite two-player games that corresponds to these properties and investigate the existence of winning strategies. We show how the presence of winning strategies for each player characterizes these separability-type notions.

Acknowledgment. This work is supported by the Scientific Research Projects Coordination Unit of Hacettepe University (Project No: FHD-2025-21908).

Keywords: topological games, separability, selection principles.

References

[1] Lj.D.R. Kočinac, S. Özcağ, (2011) Versions of separability in bitopological spaces, *Topology Appl.* **158** (2011), 1471–1477.
[2] Lj.D.R. Kočinac, S. Özcağ (2021) More on selective covering properties in bitopological spaces, *Journal of Mathematics*, Article ID 5558456.
[3] G. Gruenhage, M. Sakai (2011) Selective separability and its variations, *Topology Appl.* **158**, 1352–1359.

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Mortgage Lending Demand in the Eurozone over the 2012Q1–2025Q4 Period

P. Peshev, R. Stamenova

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Current study scrutinizes the long-run and short-run determinants of household mortgage lending across 21 eurozone countries over the period 2012Q1–2025Q4, employing a Pooled Mean Group Autoregressive Distributed Lag (PMG-ARDL) framework. Using a panel of 1178 observations, the model is specified with house price indices (LNHPI), mortgage interest rates (IRH), government bond yields (GB), real GDP (LNGDP), and unemployment (UNE) as dynamic regressors. A Hausman test confirms the validity of the PMG estimator, supporting the hypothesis of long-run slope homogeneity across countries. The long-run results indicate that house prices and GDP exert significant positive effects on household mortgage lending dynamics, while mortgage rates and government bond yields exert significant negative pressure, consistent with cost-of-funds and monetary transmission mechanisms. The error correction term confirms cointegration and indicates that the deviation from the long-run equilibrium is corrected in the short term. Short-run GDP growth exerts a significant negative effect across multiple lags, suggesting countercyclical lending rate behaviour in the near term. These findings have implications for monetary policy transmission, macroprudential regulation, and the understanding of housing finance dynamics within the European banking system.

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Bank Lending, Monetary Transmission, and Financial Reform in China: A Review of the Contemporary Literature

P. Peshev, V. Karavasileva, N. Hadzhiyski, T. Radev

University of National and World Economy, Sofia, Bulgaria

This paper provides a structured review and synthesis of the empirical literature on bank lending in China, integrating evidence from over four decades of research spanning institutional reform, monetary policy transmission, credit allocation, real-sector outcomes, and emerging sustainability and digital finance dimensions. Drawing on a curated corpus of more than forty peer-reviewed studies and policy papers, we identify four principal research clusters: *(i)* the persistence of state-directed lending bias and its welfare implications for SOEs versus private borrowers; *(ii)* the mechanisms and limits of monetary policy transmission through the bank lending channel under China's hybrid toolkit of reserve requirements, benchmark rates, and administrative guidance; *(iii)* the role of formal bank credit—relative to informal and trade credit—in supporting firm productivity, export dynamics, and household finance; and *(iv)* the emerging intersections of bank lending with fintech disruption, green credit policy, ESG-based credit signals, and AI-driven risk assessment. Our synthesis highlights that lending outcomes in China cannot be divorced from the political economy of state ownership, career-incentive structures of local officials, and the regulatory architecture governing bank competition. We further document a convergent research gap: the micro-level heterogeneity of banks and borrowers is systematically underweighted in policy evaluations that rely on aggregate or provincial data. The paper contributes an integrated conceptual map of the field, identifies outstanding empirical puzzles—including the causal channels through which digital finance and green credit policy jointly affect credit allocation efficiency and bank stability—and proposes a research agenda that bridges institutional, monetary, and sustainability perspectives on Chinese bank lending.

Acknowledgement. This work was financially supported by the UNWE Research Programme (Research Grant No. 29/2025/A).

Keywords: Bank lending in China; Monetary policy transmission; Credit allocation; State-owned banks; Financial reform in China; green finance

JEL Codes: G21; G28 ; E51; E52; P34

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Peakon Solutions for the Camassa-Holm Type Equations with Quadratic Nonlinearities

Yonghong Chen, Mingxuan Zhu, Zhijun Qiao

The University of Texas Rio Grande Valley, Edinburg, TX, USA

In this online talk, we show the multi-peakon dynamical system of a class of Camassa-Holm-type equations with quadratic nonlinearities. We also consider the analytical properties for the Cauchy problem.

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Dynamics of Algal Biofouling of Microplastics in the Ocean

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Empirical studies show that microplastics are lost in deep water layers. Understanding their trajectories and attempting to determine their location is important. We will discuss a 3-dimensional dynamical system's model describing the trajectory of microplastics with a variable amount of algal biofouling. We will consider an example of a specific water environment, microplastics and algae, and show that due to accumulation and death of algae, microplastics bounces between the lower and upper water layers, but eventually stabilizes at a specific depth.

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A Vectorial Darboux Transformation for the Fokas-Lenells Equation

Rusuo Ye

Wenzhou University, China

In this talk, based on the framework of bidifferential calculus and recent literature, a vectorial binary Darboux transformation is derived for the first member of the 'negative' part of the potential Kaup-Newell hierarchy, which is a system of two coupled Fokas–Lenells equations. Miura transformations are found from the latter to the first member of the 'negative' part of the AKNS hierarchy and also to its 'pseudodual'. The reduction to the Fokas–Lenells equation is implemented and exact solutions with a plane wave seed generated.

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Parametric Finite Element Analysis of Depth-Dependent Nanoindentation Response under Masticatory Loading-Relevant Conditions

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Surface- and depth-dependent mechanical changes, potentially associated with polishability and fluid imbibition, may influence the local material response under conditions relevant to masticatory loading. A computational framework is proposed for the analysis of nanoindentation responses in materials exhibiting depth-dependent mechanical behavior at the micro-scale. The material is represented through an equivalent two-region description, employed as a modeling approximation rather than implying physically distinct layers, in order to capture variations in the effective mechanical response with indentation depth. Within a parametric finite element formulation, two sources of influence are systematically examined: the assumed extent of the near-surface region and the functional form of the isotropic hardening law. Three constitutive models – Ludwik, Swift, and Voce – are considered. The results show that the assumed near-surface thickness has a pronounced effect on the predicted load–displacement response, while the choice of hardening law affects the quantitative response within each thickness configuration. The framework provides a computational pathway for interpreting nanoindentation responses in layered or gradient systems that deviate from bulk, mechanically homogeneous behavior, and for systematically analyzing depth-dependent behavior within a controlled parametric setting.

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Audio Transformers for Wildfire Sound Detection – A Comparative Analysis

S. Rizanov

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Wildfires emit audible and infrasound acoustic waves, with the type of burning biomass fuel and its amount directly influencing spectral characteristics. A large portion of the power density is contained within the 20Hz-100Hz band, with the bandwidth being affected by fire severity. Additionally, observed are spectral spikes in the infrasound range related to the fire flickering frequencies, with these spikes being shifted as a function of wildfire size. A final component is the presence of high frequency components, resultant from atmospheric inhomogeneities which are related to the release of thermo-mechanical stress in biomaterials.

From this it can be concluded that wildfire sound measurements are representative of non-stationary time series data, with environmental parameters directly influencing band energies, spectral centroids, bandwidths, zero-crossing rates, temporal modulation spectra and scattering features.

Within this work the goal is to perform a comparative analysis of different computational methods for distinguishing between fire from non-fire states, based purely on acoustic wave time-series analysis. Of interest is to utilize state-of-the-art audio transformers such as: AST (Audio Spectrogram Transformer); PANN (Pretrained Audio Neural Networks); PaSST (Patchout faSt Spectrogram Transformer); HTS-AT (Hierarchical Token-Semantic Audio Transformer). The model training, testing and comparison is performed over a novel labeled and balanced dataset, which includes sound samples for: fire sounds; rain; wind; branch cracking; bird sounds; animal steps. The algorithmic comparison procedure is conducted based on model accuracy and a macro-F1 metric.

Finally, an evaluation of the different models is done, which relates to temporal-permutation control. This step involves the shuffling of data time orders in order to assess the classifiers' capabilities of capturing process dynamics and not purely static distributional features.

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Dynamical Threshold for the L^2-critical NLS with a Perturbation

Shihui Zhu

Sichuan Normal University, Chengdu, China

In this talk, we consider the L^2-critical nonlinear Schrödinger equation with a perturbation. First, by constructing different functionals and constrained variational problems, we investigate the sharp threshold for blow-up and global existence of solutions. Then, by utilizing profile decomposition and concentration compactness principle, we derive the orbital stability, and we realize that this result is sharp. Finally, strong instability of standing waves is shown by the sharp threshold of blow-up solutions.

This work is joint with Guoyi Fu, Shanshan Fu and Jian Zhang.

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Electromagnetic Field-induced Metric Perturbations in General Reltivity: A Weak-field Analytical Framework

A. Da Silva, V. Traneva

Prof. Dr. Asen Zlatarov State University of Burgas, Bulgria

This paper develops a mathematical framework for analyzing the interaction between electromagnetic fields and space-time geometry within the theory of General Relativity. The study focuses on the influence of energy distributions on local metric perturbations. Starting from the Einstein field equations, the contribution of electromagnetic fields is incorporated into the stress–energy tensor. Under the weak-field approximation, the problem is reduced to a system of coupled equations describing small perturbations of the metric. Analytical solutions are derived for simplified configurations, and their qualitative behavior is examined. The results provide insight into the relationship between energy input and the resulting modification of the gravitational field. The analysis is restricted to theoretical conditions within classical General Relativity and does not imply practical realizability. The proposed framework establishes a basis for further analytical and numerical studies of field–geometry interactions.

Key words: General Relativity, wave equation, Newtonian approximation, spacetime curvature

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Analytical and Numerical Modelling of Vibrations of Thin-Walled Elastic Structures Based on Potential Theory

G.Shyshkanova, T.Zaytseva, O.Korotunova

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The paper considers problems arising in the mathematical modelling of vibrations of membranes, plates, and thin shells whose planform is close to circular. Such structures are widely encountered in solid mechanics, structural engineering, acoustics, vibration diagnostics, roofing elements, acoustic resonators, and various engineering systems whose performance is sensitive to natural frequencies and vibrational stability is of critical importance. Even small deviations of the boundary shape from a circle may significantly affect the spectral characteristics of a structure. Therefore, the development of analytical and numerical methods capable of accounting for geometric perturbations of the domain and providing stable computational schemes for spectral problems is of both theoretical and practical importance. The mathematical formulation of the considered vibration problems leads to boundary value problems for the Helmholtz equation as well as to higher-order differential equations arising in the theory of vibrating. Using the method of Bessel potentials, the original boundary value problems are reduced to systems of integral equations. This approach reduces the determination of eigenvalues to the evaluation of infinite determinants. The convergence of the resulting determinants is established, and the validity of the proposed procedure is justified. The obtained representations are written in a form analogous to Bolotin-type formulas, making them suitable for the practical implementation of successive approximation methods for eigenvalue computations. The proposed approach is aimed at the computation of eigenvalues and provides an effective tool for investigating the spectral properties of thin objects close to circular in shape. It allows one to analyse the influence of geometric perturbations on natural frequencies and vibration modes and may serve as a basis for the development of further numerical algorithms.

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Breather Solutions for the Nonlinear Wave Equation in Inhomogeneous Media

Shuguan Ji

Northeast Normal University, Changchun, China

In this talk, we consider the nonlinear wave equation in inhomogeneous media, which is modeled by the variable coefficient wave equation. By taking the periodic solutions as a breakthrough, we study the dynamical complexity of its solutions and find the essentially different dynamical behaviors for the spatially inhomogeneous wave equation.

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Quasi-Monte Carlo Sensitivity Analysis of the UNI-DEM Atmospheric Chemistry Model

V. Todorov

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This paper presents a comparative sensitivity analysis of the UNI-DEM atmospheric chemistry model using several classes of deterministic and randomized quasi-Monte Carlo methods. The study focuses on the efficient numerical estimation of multidimensional integrals arising in the computation of sensitivity indices for selected chemical species and model parameters. In particular, lattice rules, modified Sobol sequences, and polynomial lattice rules are applied and compared with respect to their accuracy, stability, and computational efficiency.

The main objective is to evaluate the influence of uncertain input parameters, including emission levels and chemical reaction rates, on the model outputs related

to key atmospheric pollutants. Sensitivity indices are computed in order to identify the dominant factors controlling the variability of the simulated concentrations. Since the underlying integrals are high-dimensional and may exhibit nontrivial dependence structures, the choice of sampling strategy is essential for obtaining reliable estimates with a feasible number of model evaluations.

Special attention is given to the performance of rank-1 lattice rules, Sobol-type low-discrepancy sequences with suitable modifications, and polynomial lattice rules constructed over finite fields. The numerical results demonstrate that quasi-Monte Carlo approaches can substantially improve the convergence behavior compared with standard Monte Carlo sampling, especially when the integrands possess sufficient regularity or effective low-dimensional structure. Among the tested approaches, polynomial lattice rules and modified Sobol sequences show strong potential for reducing the relative error in the estimation of first-order and total sensitivity indices.

The obtained results confirm the applicability of advanced low-discrepancy methods to sensitivity analysis in large-scale environmental modeling. The study also highlights that no single method is uniformly superior for all pollutants, parameters, and numerical settings, which motivates a careful method selection depending on the structure of the model response. Overall, the proposed computational framework provides a robust basis for identifying influential atmospheric processes and supporting uncertainty-aware interpretation of UNI-DEM simulations.

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A Functional Block Modeling Approach for Extreme Light-induced Nuclear Excitation Processes

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The treatment of nuclear waste remains a significant challenge in modern energy systems. Recent advances in extreme light (EL) technologies suggest the possibility of influencing nuclear excitation processes and modifying decay characteristics. This work proposes a mathematical framework for analyzing such processes through a functional block modeling approach. The system is decomposed into interconnected functional blocks describing the key physical mechanisms. Two excitation pathways are considered: (i) photon-induced excitation via inverse Compton scattering, and (ii) electron- induced excitation resulting from avalanche processes. The latter is modeled using Zakharov- type equations governing the interaction between the electric field and electron density. Each block is described analytically, allowing the integration of physical processes into a unified computational structure.

As an illustrative component, the electric dipole transition mechanism for nuclear photo-excitation is analyzed using known nuclear wave functions. The proposed framework enables the estimation of excitation efficiency and supports quantitative evaluation of the amount of processed material per laser shot. The results show that the proposed approach provides a consistent link between physical modeling and computational analysis. It offers a structured basis for future studies on optimization and cost-effectiveness of extreme light–based technologies.

Key words: nuclear waste, extreme light, nuclear excitation, inverse Compton scattering, Zakharov equations

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InterCriteria Analysis of Physicochemical Quality Indicators in Commercial Gasoline Samples

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The assessment of gasoline quality requires the simultaneous evaluation of multiple physicochemical indicators, including octane numbers, density, sulfur content, hydrocarbon composition, oxygenates, vapor pressure, and distillation characteristics. The existence of hidden dependencies among these indicators often complicates the interpretation of laboratory results and may lead to redundant measurements. This study investigates the applicability of InterCriteria Analysis (ICrA) for identifying relationships among quality indicators of commercial gasoline samples. Experimental data from five gasoline samples are analyzed using the apparatus of intuitionistic fuzzy sets and index matrices. The considered criteria include research octane number (RON), motor octane number (MON), density, sulfur content, olefins, aromatics, benzene, oxygen content, ethanol content, vapor pressure, and selected distillation parameters. The InterCriteria Analysis is employed to determine the degrees of consonance and dissonance between the investigated indicators and to reveal hidden dependencies within the dataset. The obtained results demonstrate the presence of significant relationships among octane characteristics, hydrocarbon composition, oxygen-containing components, and distillation properties. Several indicators exhibit high levels of agreement, suggesting the possibility of reducing the number of laboratory measurements without substantial loss of information.

The study confirms that InterCriteria Analysis is an effective mathematical tool for the exploration of complex petroleum datasets and can support intelligent quality assessment, process optimization, and decision-making in petroleum refining. The proposed approach contributes to the development of interpretable data-analysis methodologies for industrial applications and demonstrates the practical usefulness of intuitionistic-fuzzy techniques in fuel- quality evaluation.

Keywords: InterCriteria Analysis, intuitionistic fuzzy sets, gasoline quality assessment, petroleum products, physicochemical indicators, data analysis.

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New S-Integrable Nonlinear Evolution Equations with Additional Constraints

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We consider multicomponent nonlinear partial differential equations in two independent variables that have a zero curvature representation. Their Lax pair is a linear bundle in pole gauge related to a simple Lie algebra. Moreover, the potential is subject to some differential constraint. A simple example that belongs to this class of nonlinear evolution equations include the well-known Heisenberg ferromagnet equation and some of its generalizations related to an arbitrary simple Lie algebra.

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Migration Dynamics in a Spatial Model with Myopic Agents

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This work develops a model of the migration decisions of a heterogeneous population of economic agents who relocate in economic space in search of better

remuneration opportunities. Agents are myopic in the sense that they have informat-ion on wages only in a neighborhood of their current location and they solve a static utility maximisation problem. The evolution of the population distribution is studied in one-dimensional economic space for different wage distributions and model param-etrisations.

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