Fifth ROMANIAN ITINERANT SEMINAR ON MATHEMATICAL ANALYSIS AND ITS APPLICATIONS

Craiova, 26–28 May 2023

Book of Abstracts and Program

Contents

Opening Speech

by Professor Gheorghe Moroşanu (Babeş Bolyai University)

Dear Colleagues, welcome to the fifth meeting of the Romanian Itinerant Seminar on Mathematical Analysis and its Applications (RISMAA 2023) !

Let me start by saying that I launched this itinerant seminar in 2017 and I am sharing coordination responsibilities with my colleagues Adrian Petrușel and Radu Precup, both from *Babeş-Bolyai* University in Cluj-Napoca. This year, on February 9, Professor Adrian Petrușel turned 60. I greatly appreciate his contributions to mathematics, education, and especially to this itinerant seminar, so let's dedicate this fifth RISMAA meeting to him.

Dear Adrian, congratulations and all the best !

Let me remind everyone that the previous meetings of RISMAA were organized at the following institutions: *Babeş-Bolyai* University in Cluj-Napoca (2018), *Ovidius* University in Constanţa (2019), University of Alba Iulia (2021), and *Transylvania* University in Braşov (2022). They were all quite successful and demonstrated RISMAA's increased popularity among people interested in the respective fields. Unfortunately, due to the COVID-19 pandemic, the third edition of RISMAA took place in 2021 instead of 2020, in a hybrid format rather than the traditional in-person format.

It is worth mentioning that our conference participants benefit a lot from our presentations and discussions on various topics, which stimulate creativity and lead to new scientific results. Moreover, participation in the RISMAA conferences counts towards academic promotion and tenure for our colleagues from Romania and abroad.

Here we are at the University of Craiova for the fifth RISMAA meeting, which is organized by a local committee coordinated by Professor Cristian Vladimirescu (Director of the Applied Mathematics Department of the University of Craiova).

Many thanks to Cristian for his extraordinary efforts over the last several months !

This time, the participants are mostly attending the conference in-person. For this edition of RISMAA, the plenary lectures will be delivered by the following invited distinguished colleagues (in alphabetical order):

- **Adriana BUICĂ**, Babeş-Bolyai University, Cluj-Napoca, Romania
- **Liviu IGNAT**, Institute of Mathematics "Simion Stoilow" of the Romanian Academy, Bucharest, Romania
- **Sorin MICU**, University of Craiova, Romania
- **Mihai MIHĂILESCU**, University of Craiova, Romania & "Gheorghe Mihoc - Caius Iacob" Institute of Mathematical Statistics and Applied Mathematics of the Romanian Academy, Bucharest, Romania

Good luck to everybody !

List of Participants

1. Sebastian ANIŢA, Faculty of Mathematics, "Alexandru Ioan Cuza" University of Iaşi, Romania & "Octav Mayer" Institute of the Romanian Academy, Iaşi, Romania
2. Maria-Magdalena BOUREANU, University of Craiova, Romania
3. Adriana BUICĂ, Babeș-Bolyai University, Cluj-Napoca, Romania
4. Cristian CAZACU, University of Bucharest & "Gheorghe Mihoc - Caius Iacob" Institute of Mathematical Statistics and Applied Mathematics of the Romanian Academy, Bucharest, Romania
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11. Raluca EFREM, University of Craiova, Romania
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16. Nataliia KOLUN, Babeş-Bolyai University, Cluj-Napoca, Romania

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28. Adrian PETRUŞEL, Babeş-Bolyai University, Cluj-Napoca, Romania

29. Gabriela PETRUŞEL, Babeş-Bolyai University, Cluj-Napoca, Romania

30. George POPESCU, University of Craiova, Romania

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33. Vladimir RĂSVAN, Romanian Academy of Engineering Sciences (ASTR), Bucharest, Romania & University of Craiova, Romania

34. Denisa STANCU-DUMITRU, University Politehnica of Bucharest, Romania & ICUB, University of Bucharest, Romania

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Abstracts of Plenary Lectures

Bifurcations from a normally degenerate cycle in forced planar differential equations

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Abstract. Bifurcations of periodic solutions from a resonant period manifold in forced differential systems are intensively studied in the literature, usually assuming that the period manifold is normally non-degenerate.

In this talk we consider smooth systems in dimension two, considering bifurcations from a normally degenerate cycle. The complexity of this situation is characterized in terms of the Poincaré return map and return-time map near the cycle of the unperturbed system. A geometric setting is defined to analyze the Poincaré translation map of the perturbed system.

Asymptotic behavior of solutions for some diffusion problems on metric graphs

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Abstract. In this talk we present some recent result about the long time behavior of the solutions for some diffusion processes on a metric graph. We study evolution problems on a metric connected finite graph in which some of the edges have infinity length. We show that the asymptotic behaviour of the solutions of the heat equation (or even some nonlocal diffusion problems) is given by the solution of the heat equation, but on a star shaped graph in which there is only one node and as many infinite edges as in the original graph. In this way we obtain that the compact component that consists in all the vertices and all the edges of finite length can be reduced to a single point when looking at the asymptotic behaviour of the solutions. We prove that when time is large the solution behaves like a gaussian profile on the infinite edges. When the nonlinear convective part is present we obtain similar results but only on a star shaped tree.

Acknowledgment: This is a joint work with Cristian Cazacu (University of Bucharest, cristian.cazacu@fmi.unibuc.ro), Ademir Pazoto (Federal University of Rio de Janeiro, ademirim.ufrj.br), Julio D. Rossi (University of Buenos Aires, julio.d.rossigmail.com) and Angel San Antolin (University of Alicante, a.sanantolingmail.com).

On the approximation of controls for hyperbolic equations

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Abstract. We analyze a method for the approximation of exact controls of a second order infinite dimensional system with bounded input operator. The algorithm combines Russell's "stabilizability implies controllability" principle and a finite elements methd of order θ with vanishing numerical viscosity. We show that the algorithm is convergent for any initial data in the energy space and that the error is of order θ for sufficiently smooth initial data. Both results are consequences of the uniform exponential decay of the discrete solutions guaranteed by the added viscosity.

Monotonicity properties of the p-torsional rigidity in convex domains

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Abstract. For any bounded and convex set $\Omega \subset \mathbb{R}^N$ $(N \geq 2)$ with smooth boundary, $\partial\Omega$, and any real number $p > 1$, we denote by u_p the *p-torsion function* on Ω, that is the solution of the *torsional creep problem* $\Delta_p u = -1$ in Ω, $u = 0$ on $\partial\Omega$, where $\Delta_p u := div(|\nabla u|^{p-2}\nabla u)$ is the p-Laplace operator. Our aim is to investigate the monotonicity with respect to p for the *p-torsional rigidity* on Ω, defined as $T_p(\Omega) := \int_\Omega u_p dx$. More precisely, we show that there exist two constants $D_1 \in \left[\frac{1}{2}, e^{\frac{-1}{N+1}}\right]$ and $D_2 \in [1, N]$ such that for each bounded and convex set $\Omega \subset \mathbb{R}^N$ with $\frac{|\partial\Omega|}{|\Omega|} \leq D_1$ the function $p \to T_p(\Omega)$ is decreasing on $(1, \infty)$ while for each bounded and convex set $\Omega \subset \mathbb{R}^N$ with $\frac{|\partial\Omega|}{|\Omega|} \geq D_2$ the function $p \to T_p(\Omega)$ is increasing on $(1, \infty)$. Moreover, for each real number $s \in (D_1, D_2)$ there exists a bounded and convex set $\Omega \subset \mathbb{R}^N$ with $\frac{|\partial\Omega|}{|\Omega|} = s$ such that the function $p \to T_p(\Omega)$ is not monotone on $(1, \infty)$. This is a joint work with Cristian Enache and Denisa Stancu-Dumitru.

Abstracts of Short Presentations (alphabetical order by presenters' surname)

Predators as a possible strategy for controlling an epidemic

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Abstract. A spatially structured mathematical model has been proposed to include a predator as a possible biocontrol agent of an epidemic. The situations when the predator is generalist or specialized are discussed. A special attention is shown to the OQDS outbreak caused by the bacterium *Xylella fastidiosa*.

2020 Mathematics Subject Classification: 35-XX, 35B40, 37N25, 92C80, 92D30, 92D40, 93B99.
Key words and phrases: epidemics, reaction-diffusion models, control strategies.

The Hardy inequality and asymptotic behavior of the heat equation on $\mathbb{R}^{N-k} \times (0,\infty)^k$

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Abstract. We study the large time asymptotic behaviour of the heat equation with Hardy inverse-square potential on generalized half-spaces $\mathbb{R}^{N-k} \times (0,\infty)^k$, $k \geq 0$. We first show a new improved Hardy-Poincaré inequality for the quantum harmonic oscillator with Hardy potential. Then we obtain optimal polynomial time decay rates and the first term in the asymptotic expansion of the solutions in $L^2(\mathbb{R}^{N-k} \times (0,\infty)^k)$. Particularly, we extend and improve the results obtained by Vázquez and Zuazua (J. Funct. Anal. 2000) (which correspond to the case $k = 0$) to any $k \geq 0$. We emphasize that the higher the value of k the better time decay rates are. We employ a simplified approach conceding to remove the usage of spherical harmonics decomposition in our analysis.

This talk is based on a joint work with Liviu Ignat (Institute of Mathematics of the Romanian Academy-IMAR, Bucharest, Romania) and Dragos Manea (PhD student, IMAR).

Partially supported by a grant of the Ministry of Research, Innovation and Digitization, CNCS - UEFISCDI, Romania, project number PN-III-P1-1.1-TE-2021-1539, within PNCDI III.

2020 Mathematics Subject Classification: 35A23, 35B40, 35K67, 46E35.
Key words and phrases: asymptotic behaviour, Hardy inequality, inverse-square potential, heat equation, self-similarity variables.

Optimization problems governed by approximately star-shaped functionals

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Abstract. In this talk, we establish the connections between the solutions of some classes of variational control inequalities of vector type, denoted by (VVI) and $(WVVI)$, and (local, weak) quasi-efficient solutions of the associated multiobjective optimization problem, denoted by (MVP). In this regard, we use the local (strictly) approximately star-shaped and/or local approximately pseudo-convex properties of the involved functionals. In addition, an illustrative application is also presented that verifies the statements and the theoretical results.

2020 Mathematics Subject Classification: 26B25, 49J40, 90C30.
Key words and phrases: local (strictly) approximately star-shaped functional, local approximately pseudo-convex functional, variational control inequality, multiobjective optimization problem.

Pricing European- and American-type options under stochastic volatility: a computational study

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Abstract. We describe a stabilized finite element formulation for pricing European- and American-type options under Heston's stochastic volatility model. The streamline-upwind/Petrov–Galerkin (SUPG) formulation constitutes the core of our computational approach. We also enhance the SUPG-stabilized formulation with a discontinuity-capturing mechanism. The Crank–Nicolson scheme is used to perform temporal discretization. We add a penalty term to the associated discrete formulation to address the linear complementarity problems that emerge when solving American-style option pricing models. The Newton–Raphson algorithm is used to solve nonlinear algebraic equation systems, and the BiCGStab method, preconditioned with the ILU technique, is employed to solve linearized systems. We present several comparisons to demonstrate the performance of the proposed formulation and techniques.

2020 Mathematics Subject Classification: 65M60, 91G30.
Key words and phrases: Option pricing, finite elements.

Existence results for solutions of a Caputo-Fabrizio fractional differential inclusion with anti-periodic boundary conditions

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Abstract. We consider the following boundary value problem

$$D^r_{CF}x(t) + \lambda x(t) \in F(t, x(t)) \quad a.e.\ ([0,T]), \quad x(0) = -x(T),$$

where $F(.,.) : [0,1] \times \mathbb{R} \to \mathscr{P}(\mathbb{R})$ is a set-valued map, $\lambda > 0$ and D^r_{CF} denotes Caputo-Fabrizio's fractional derivative of order $r \in (0,1)$.

Some existence results for this problem are established. The results are obtained under several hypotheses concerning the regularity of the set-valued map F and are based on a nonlinear alternative of Leray-Schauder type, on Bressan-Colombo selection theorem for lower semicontinuous set-valued maps with decomposable values and on Kuratowski and Ryll-Nardzewski selection theorem.

2020 Mathematics Subject Classification: 26A33, 34A08, 34A60.
Key words and phrases: fractional derivative, differential inclusion, fixed point, selection.

Interval-valued optimal control problems and associated variational control inequalities

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Abstract. In this talk, the principal purpose is to investigate the connections between a class of interval-valued variational control problems and the associated variational control inequalities. Concretely, by considering the solutions of the corresponding (weak, split) variational control inequalities, we establish several results on the existence of (strong) LU-optimal solutions for the interval-valued optimization problem under study. In this regard, the LU-convexity property of the involved functionals plays an important role. In addition, an illustrative application is also presented that verifies the statements and the theoretical results.

2020 Mathematics Subject Classification: 26B25, 49J40, 90C30.
Key words and phrases: LU-optimal solution, LU-convexity, interval-valued optimization problem, variational control inequality.

Modulated waves as spatial-temporal patterns in a model of neural activity

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Abstract. This paper studies the existence and properties of several spatial-temporal patterns in a system of integral-differential equations: traveling waves, standing waves, and modulated waves. We identify sufficient conditions on the model's parameters for the generation of such patterns, then use numerical simulations to illustrate the model dynamics.

2020 Mathematics Subject Classification: 37G05, 92B20.
Key words and phrases: waves, pattern formation, spatial-temporal dynamics.

On the stochastic linear quadratic optimal control problem by piecewise constant controls. The infinite horizon time case

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Abstract. We investigate the problem of indefinite stochastic linear quadratic optimal control by piecewise constant controls in an infinite horizon case. By restricting the set of admissible controls to the class of piecewise constant stochastic processes, we reformulated the above control problem under the setting of systems modelled by Itô differential equations controlled by impulses. We show that the solution in a state feedback form of the indefinite stochastic linear quadratic control problem is equivalent to the existence of a global stabilizing solution associated to a class of backward matrix linear differential equations with a Riccati type jumping operators.

2020 Mathematics Subject Classification: 49N10, 49N45.
Key words and phrases: stochastic linear quadratic optimal control, piecewise constant controls, infinite horizon, generalized Riccati equations.

Stability and bifurcation analysis of an epidemic model

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Abstract. This work investigates the dynamics of a SEIR type epidemic model, incorporating a general nonlinear infection-dependent incidence and removal rates. The basic reproduction number, which governs the survival and extinction of diseases, is determined. Apart from the disease free equilibrium point, we proved that the model may exhibit at most two endemic equilibria, depending on the threshold condition. The local asymptotical stability of equilibria is determined, proving that there exist several scenarios when the system possesses either two stable equilibria either a stable equilibrium and a stable limit cycle. Forward and backward transcritical bifurcation are established under sufficient circumstances. The theoretical findings are supported and supplemented by numerical simulations.

2020 Mathematics Subject Classification: 37G35, 34C23,37M05 .
Key words and phrases: epidemic model, equilibria,asymptotical stability, bifurcation.

Radial solutions for nonlinear elliptic equations with singular potentials

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Abstract. In this talk, we present recent results on the existence of radial solutions for some nonlinear elliptic equations with singular potentials. This is joint work with Florica Cîrstea. The presentation is partially supported by CNCS-UEFISCDI Grant No. PN-III-P1-1.1-PD-2021-0037.

The torsion problem of the p-Bilaplacian

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Abstract. For each bounded and open set $\Omega \subset \mathbb{R}^N$ $(N \geq 2)$ with smooth boundary denoted by $\partial\Omega$ and each real number $p \in (1, \infty)$ we analyze the torsion problem of the p-Bilaplacian, namely $\Delta(|\Delta u|^{p-2}\Delta u) = 1$ in Ω with $u = \Delta u = 0$ on $\partial\Omega$. Firstly, we show that for each $p \in (1, \infty)$ the problem has a unique weak solution u_p. Secondly, we prove that u_p converges uniformly, as $p \to \infty$, in $C^1(\overline{\Omega})$ to a certain function, say v_2, which is exactly the unique solution of the problem $-\Delta u = 1$ in Ω with $u = 0$ on $\partial\Omega$. Next, we show that each solution u_p is also a solution for the minimization problem

$$\mathscr{T}(p;\Omega) := \inf_{u \in \mathscr{X}_p(\Omega)\setminus\{0\}} \frac{\dfrac{1}{|\Omega|}\displaystyle\int_\Omega |\Delta u|^p \, dx}{\left(\dfrac{1}{|\Omega|}\displaystyle\int_\Omega u \, dx\right)^p},$$

where $\mathscr{X}_p(\Omega) := \{u \in W^{2,p}(\Omega) \cap W_0^{1,p}(\Omega) : \ u(x) \geq 0, \ a.e. \ x \in \Omega\}$. Further, we show that the function $(1, \infty) \ni p \mapsto \mathscr{T}(p;\Omega)$ is strictly increasing provided that Ω is a convex and bounded open set for which $|\Omega|^{-1}\int_\Omega v_2 \, dx$ is small. Finally, using this monotonicity result, we give an alternative variational characterization of the constant $\mathscr{T}(p;\Omega)$ when $|\Omega|^{-1}\int_\Omega v_2 \, dx$ is small. That last variational characterization fails to hold true when $|\Omega|^{-1}\int_\Omega v_2 \, dx > 1$. This is based on a joint work with Mihai Mihăilescu.

Shape parameters influence of some radial basis functions on solution of singular boundary integral equation of the compressible fluid flow around obstacles

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Abstract. A study about the influence of shape parameters of some radial basis functions on solution of singular boundary integral equation of the compressible fluid flow around obstacles is made. The solution is obtained by using a meshless method for the problem of compressible fluid flow around obstacle, based on the singular boundary integral equation with sources distribution combined with radial basis functions interpolation. RBFs depend on distances to centers and on shape parameters which have a great influence on numerical solutions accuracy. Optimal values for some shape parameters are obtained by considering analytical solutions which exist in some particular cases. Two types of radial basis functions are used in this approach, namely Gaussians and Multiquadric and comparisons between different solutions are also made.

Energy-based localization of positive solutions for stationary Kirchhoff type equations

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Abstract. We are concerned with positive solutions for the Dirichlet boundary value problem for stationary Kirchhoff type equations

$$\begin{cases} -\eta(|u|_{H_0^1})u'' = f(x,u), & \text{a.e. } x \in (0,1) \\ u(0) = u(1) = 0, \end{cases}$$

where $\eta \in C(\mathbb{R}_+, \mathbb{R}_+)$ is an increasing function, $f : [0,1] \times \mathbb{R}_+ \to \mathbb{R}_+$ is an L^2-Carathéodory function and

$$|u|_{H_0^1} = \left(\int_0^1 u'^2 \right)^{\frac{1}{2}}$$

is the energy norm.

We obtain existence and localization results of positive solutions using Krasnosel'skiĭ's fixed point theorem in cones and a weak Harnack type inequality. The localization is given in terms of energy norm, being of interest from a physical point of view.

This work was written by co-authors Nataliia Kolun and Radu Precup.

2020 Mathematics Subject Classification: 34K10, 47J05.
Key words and phrases: Kirchhoff equation, positive solution, Dirichlet boundary value problem, Krasnosel'skiĭ's fixed point theorem in a cone, weak Harnack inequality.

A semigroup approach for generalized dichotomies of evolution families

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Abstract. We introduce a special class of real semiflows, which is used to define a general type of evolution semigroups, associated to not necessarily exponentially bounded evolution families. Giving spectral characterizations of the corresponding generators, our results directly apply to a wide class of dichotomies, such as those with time-varying rate of change.

The presentation is based on the following papers:

[1] N. Lupa, L.H. Popescu, Generalized exponential behavior on the half-line via evolution semigroups, Carpathian Journal of Mathematics 38 (3), 691-705, 2022.

[2] N. Lupa, L.H. Popescu, Generalized evolution semigroups and general dichotomies, Submitted, arXiv:2206.05996 [math.CA].

2020 Mathematics Subject Classification: 34D09, 34G10, 47D06.
Key words and phrases: Evolution families, evolution semigroups, hyperbolicity, dichotomies.

Inner product on the space of convex and compact sets

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Abstract. In this paper, we introduced an inner product on the space of convex and compact sets and the properties of this inner product are studied.

Three-field weak solutions for frictional contact models with prescribed normal stress

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Abstract. In the present talk we focus on nonlinear boundary value problems that model the frictional contact with prescribed normal stress between a deformable body and a foundation. The body is nonlinearly elastic, the constitutive law being a subdifferential inclusion. The study is based on a three-field variational formulation. In this approach, a weak solution is a triple consisting of the displacement field, a Lagrange multiplier related to the friction force and the Cauchy stress tensor.

2020 Mathematics Subject Classification: 26B25, 49J53, 49J40, 74M10, 74M15.
Key words and phrases: set-valued elastic operator, separable bipotential, Lagrange multipliers, variational inequalities, weak solution.

Angular distribution of zeros of polynomials whose coefficients exhibit specific sign patterns

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Abstract. The classical result that a polynomial with nonnegative coefficients does not have zeros in a sector around the real axis that depends only on the degree of the polynomial is extended with geometric arguments to polynomials whose coefficients have different sign patterns. This result is then used not only to improve the aforementioned classical result, but also to complement theorems by Hayashi and Hurwitz, which only concern the magnitude of the zeros, with the angular distribution of the zeros as well.

It is also shown how these results can be applied to polynomial eigenvalue problems, which occur in many engineering areas.

2020 Mathematics Subject Classification: 15A18, 30C15, 65H04.
Key words and phrases: angular distribution, polynomial zeros, matrix polynomials, Hayashi, Hurwitz.

A superconvergent spline collocation method for mixed Volterra–Fredholm integral equations of the Hammerstein type

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Abstract. We investigate a collocation method for the approximate solution of two-dimensional nonlinear mixed Volterra–Fredholm integral equations of the Hammerstein type. For a reformulation of the equation, we consider the domain of integration as a planar triangle and use a special type of piecewise linear interpolation over triangles. This leads to a numerical integration scheme with a higher degree of precision than expected, resulting in a collocation method that is *superconvergent* at the collocation nodes, meaning that at the collocation nodes it converges faster than over the entire domain. As a consequence, this procedure requires fewer iterations for a desired accuracy, thus reducing the computational cost and simplifying the implementation. The convergence of the method is established, as well as the rate of convergence. Numerical examples are considered, showing the applicability of the proposed scheme and the agreement with the theoretical results.

2020 Mathematics Subject Classification: 45D05, 45H05, 31A10, 65D05.
Key words and phrases: mixed Volterra–Fredholm integral equations, Hammerstein integral equations, spline collocation, interpolation.

Second-order differential inclusions with two small parameters

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Abstract. Let H be a real Hilbert space. Consider in H the problem

$$-\varepsilon u''(t) + \mu u'(t) + Au(t) + Bu(t) \ni f(t),\ 0 < t < T;\ \ u(0) = u_0,\ u'(T) = 0,$$

where $T > 0$ is a given time instant, ε and μ are positive parameters, $A : D(A) \subset H \to H$ is a (possibly set-valued) maximal monotone operator, and $B : H \to H$ is a Lipschitz operator. We investigate the behavior of the solutions to this problem in three cases: (i) $\mu > 0$ fixed, $0 < \varepsilon \to 0$; (ii) $\varepsilon > 0$ fixed, $0 < \mu \to 0$; (iii) both ε and μ tend to zero. Notice that if $\mu = 1$ and ε is a positive small parameter, the above problem is a Lions type regularization of the Cauchy problem

$$u'(t) + Au(t) + Bu(t) \ni f(t),\ 0 < t < T;\ \ u(0) = u_0,$$

which was previously studied by L. Barbu and G.M. [Commun. Contemp. Math. 19 (2017)]. Our abstract results are illustrated with examples related to the diffusion equation and the telegraph differential system.

2020 Mathematics Subject Classification: 34G25, 47J35, 47H05, 35K20, 35L50.
Key words and phrases: monotone operator, differential inclusion, Lions regularization, approximation, diffusion equation, telegraph system.

On the Jacobi stability of a modified SIR epidemic pattern with demography

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Abstract. In this work, we will consider a modified SIR pattern with demography. By reformulating this first order differential system as a system with two second-order differential equations, we investigate the nonlinear dynamics of the system from the Jacobi stability point of view by using the Kosambi–Cartan–Chern (KCC) geometric theory. We will determine the zero-connection curvature tensor, the nonlinear connection, the Berwald connection, and the five KCC invariants which express the intrinsic geometric properties of the system: the first invariant – the external force ε^i, the second invariant – deviation curvature tensor P^i_j, the third invariant – the torsion tensor P^i_{jk}, the fourth invariant – Riemann-Christoffel curvature tensor P^i_{jkl}, the fifth invariant – Douglas tensor D^i_{jkl}. In order to obtain necessary and sufficient conditions for the Jacobi stability of the system, the deviation curvature tensor will be determined at each equilibrium points. Furthermore, we will compare the Jacobi stability of this system with the classical linear stability, inclusive by diagrams related to the values of parameters of the system.

2020 Mathematics Subject Classification: 34D20, 37C20, 37C75, 53E10.
Key words and phrases: SIR model; KCC geometric theory; the deviation curvature tensor; Jacobi stability.

Weak solvability via bipotentials for contact models with Tresca's friction law and approximation results

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Abstract. We consider a mathematical model describing the contact between a body and a foundation. The friction is modeled by the Tresca law, while the behavior of the material is described by means of the subdifferential of a convex map ω. We define a separable bipotential involving the map ω and its Fenchel conjugate and based on this bipotential we deliver a two-field weak formulation of the model under consideration. The presence of the separable bipotential allows to study the existence and uniqueness of the pair solution by minimization techniques. We also discuss an alternative one-field formulation of the model and we illustrate the connections between these two formulations. Finally, we consider a regularization of the Tresca law and we deliver convergence results.

2020 Mathematics Subject Classification: 49J40, 49J53, 74M10, 74M15.
Key words and phrases: Tresca's friction law, subdifferential inclusion, separable bipotential, two-field weak solution, convergence results.

On approximation of unbounded functions on non-compact intervals

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Abstract. We consider the problem of approximation of unbounded functions on intervals $[0,1)$ and $[0,\infty)$, respectively using positive linear operators and the connection between the two kind of problems. A main objective is the polynomial approximation. Quantitative results are obtained using new kind of moduli of continuity.

2020 Mathematics Subject Classification: 41A36, 41A10.
Key words and phrases: approximation of unbounded functions, linear positive operators, moduli of continuity.

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Multi-valued Feng-Liu contractions and applications

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Abstract. In this talk, we will present some new results related to the concept of the multi-valued Feng–Liu contraction. An existence, approximation and localization fixed point theorem for a generalized multi-valued nonself Feng–Liu contraction and a new fixed point theorem for multi-valued Feng–Liu contractions in vector-valued metric spaces are proved. Stability results and an application to a system of operatorial inclusions are also given.

2020 Mathematics Subject Classification: 47H10, 54H25.
Key words and phrases: fixed point, metric space, multi-valued contraction of Feng-Liu type, stability properties.

Perturbations of Rhaly operators

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Abstract. We focus on Rhaly operators on separable Hilbert spaces. Such operators are defined by terraced matrices, generated by a sequence of complex numbers.

Regularity properties of the defining sequence, imply boundedness or compactness of Rhaly operators.

We prove that perturbations of the defining sequence, namely replacing just one subsequence, may preserve boundedness or compactness, only if the subsequence is rare.

Recurrence in linear dynamics

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Abstract. When we take into account geometric behavior linear operators have 6 possible types of orbits. We will discuss which of them are compatible with recurrence as well as some open problems related to linear recurrence.

Localization of solutions for semilinear problems with poly-Laplace type operators

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Abstract. The paper presents an abstract theory regarding the problems with semilinear operator equations involving iterates of a strongly monotone symmetric linear operator. We obtain existence and localization results of positive solutions for such problems using Krasnosel'skiĭ's technique and abstract Harnack inequality. In particular, we obtain results for problems with semilinear poly-Laplace operators. The work was carried out together with Dr. Nataliia Kolun.

2020 Mathematics Subject Classification: 35J40, 47J05.
Key words and phrases: Krasnosel'skiĭ's technique, fixed point, Harnack inequality, poly-Laplace type operator.

On the challenge of critical cases in certain applications described by $1D$ partial differential equations of hyperbolic type

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Abstract. There are considered engineering applications described by non-standard boundary value problems for $1D$ hyperbolic partial differential equations. The stability of the dynamic systems thus defined is discussed by associating a system of functional differential equations with deviated argument whose solutions are in one-to-one correspondence with those of the aforementioned boundary value problems. If stability in the sense of Lyapunov can be easily obtained by using an energy-like Lyapunov functional, asymptotic stability is subject to an additional requirement for the asymptotic stability of the difference operator associated to the system of functional differential equations. With respect to this aspect, there exist several applications e.g. from the theory of lossless transmission lines in Electrical Engineering or co-generation control in Thermal Power Engineering, where the stability of the difference operator is ensured.

This paper focuses however on such critical cases when the difference operator is only marginally stable i.e. its stability is non-asymptotic. It is the case of certain models associated to Mechanical and Hydraulic Engineering. Since asymptotic stability is important in applications, removing criticalities is an urgent task. There are shown two ways in this direction. The first one is to improve the model by introducing the energy dissipation terms neglected otherwise: in the energy context this is only natural. Moreover, it points to the dissipative boundary conditions discussed by S. K. Godunov. The other approach is to find a suitable state space allowing application of the Barbashin Krasovskii LaSalle principle in the framework of the critical cases.

2020 Mathematics Subject Classification: 34D20, 34K40, 34K20, 35L50.
Key words and phrases: hyperbolic partial differential equations, neutral functional differential equations, energy Lyapunov functional, asymptotic stability.

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A global implicit operator theorem in terms of monotone operators

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Abstract. Let X be a nonempty set, H a real Hilbert space and $T : X \times H \to H$ be such that $T(x, \cdot) : H \to H$ is a strongly monotone operator for each $x \in X$. In this paper we give conditions in which there exists a unique operator $\Phi : X \to H$, such that $T(x, \Phi(x)) = 0$ for all $x \in X$. If X is a metric space, and if $X = \mathbb{R}^p$ and $H = \mathbb{R}^q$ we present some properties of the implicit operator Φ.

2020 Mathematics Subject Classification: 47H10, 47J07, 65F10, 26B10, 58C15.
Key words and phrases: saturated contraction principle, Ostrowski property, implicit function problem, implicit operator problem.

A minimization problem related to the principal frequency of the p-Bilaplacian with coupled Dirichlet-Neumann boundary conditions

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Abstract. We give a new variational characterization of the principal frequency of the p-Bilaplacian with coupled Dirichlet-Neumann boundary conditions on open, bounded and convex subsets of the Euclidean space $\mathbb{R}^N$ with small inradius, when $p \in (1, \infty)$ is large enough. This is a joint work with Maria Fărcăşeanu and Mihai Mihăilescu. This presentation is partially supported by CNCS-UEFISCDI Grant No. PN-III-P1-1.1-TE-2021-1539.

2020 Mathematics Subject Classification: 35P30, 47J05, 47J20, 49J40, 49S05.
Key words and phrases: p-Bilaplacian, principal frequency, Dirichlet-Neumann boundary conditions.

The approximation of the controls for the wave equation with a lower rate numerical vanishing viscosity

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Abstract. We study with the approximation of a boundary control of the linear one-dimensional wave equation, when a lower rate numerical vanishing viscosity term is added. The high frequency spurious oscillations introduced by the classical method of space discrete numerical schemes lead to nonuniform controllability properties which are dumped out using an additional vanishing viscosity term. We are able to prove the convergence of the sequence of discrete controls to a control of the continuous wave equation, when the mesh size tends to zero. A numerical experiment which confirm our results is also presented.

2020 Mathematics Subject Classification: 93B05, 30E05, 58J45, 65N06.
Key words and phrases: wave equation, control approximation, moment problem, biorthogonal families, vanishing viscosity.

On the robustness of economic growth models to perturbation

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Abstract. Nonlinear dynamical systems tend to be sensitive to perturbations of large magnitude and hence, characterizing their resilience is of practical interest.

In this context, the present contribution deals with the highly influential economic growth model considering the evolution of the capital $k(t)$ together with that of the human capital $h(t)$ (i.e., effects of education) due to Mankiw, Romer and Weil (MRW)

$$\begin{cases} \dot{k} &= s_K k^\alpha h^\beta - ck + f_1(t), \\ \dot{h} &= s_H k^\alpha h^\beta - ch + f_2(t), \end{cases}$$

with bounded perturbations $|f_1(t)|, |f_2(t)| \leq \varepsilon$ and parameters $s_K, s_H, \alpha, \beta, c$.

Actually, for perturbations below a certain threshold, we provide an estimate for the difference between solutions of the exact (i.e., $f_1, f_2 = 0$) and perturbed models, which scales linearly with the magnitude ε of the perturbation.

Interestingly enough, the geometry of the MRW model allows for a change of coordinates that partly decouples the system, reducing the robustness analysis to an investigation of a perturbed Solow equation

$$\dot{r} \quad = \quad sr^\gamma - cr + f(t),$$

that can be analyzed exhaustively along the same lines as the standard logistic equation.

2020 Mathematics Subject Classification: 34D10.
Key words and phrases: economic growth model, perturbation.

Defining the semimodularity of the Boolean asynchronous systems

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Abstract. The semimodular Boolean asynchronous systems have been defined for the first time in [2] and their study was continued, more or less informally, in many other works such as [1], [3] and [4]. Our aim is to use the tools of [5] in revisiting these systems.

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Schedule

Friday, 26 May 2023 (Central building of the University of Craiova, 13 A.I. Cuza Str.)

14:00–14:30 Registration and coffee (Mihai I Hall)

14:30–15:00 Opening Ceremony (Mihai I Hall)

15:00–17:40 Plenary Lectures (Mihai I Hall)

Chair: Gheorghe MOROŞANU

15:00–15:40 **Adriana BUICĂ**, *Bifurcations from a normally degenerate cycle in forced planar differential equations* (p. 5)

15:40–16:20 **Liviu IGNAT**, *Asymptotic behavior of solutions for some diffusion problems on metric graphs* (p. 5)

16:20–17:00 **Sorin MICU**, *On the approximation of controls for hyperbolic equations* (p. 6)

17:00–17:40 **Mihai MIHĂILESCU**, *Monotonicity properties of the p-torsional rigidity in convex domains* (p. 6)

17:40–18:00 Coffee Break

18:00–18:40 Short Lectures, Sessions A and B

Session A (Mihai I Hall)

Chair: Vladimir RĂSVAN

18:00–18:20 **Süleyman CENGIZCI**, *Pricing European- and American-type options under stochastic volatility: a computational study* (p. 8)

18:20–18:40 **Rodica CURTU**, *Modulated waves as spatial-temporal patterns in a model of neural activity* (p. 9)

Session B (Room 444)

Chair: Denisa STANCU-DUMITRU

18:00–18:20 **Andaluzia-Cristina MATEI**, *Three-field weak solutions for frictional contact models with prescribed normal stress* (p. 13)

18:20–18:40 **Mădălina OSICEANU**, *Weak solvability via bipotentials for contact models with Tresca's friction law and approximation results* (p. 14)

19:00–20:30 Welcome Cocktail (University Restaurant)

Saturday, 27 May 2023 (Central building of the University of Craiova, 13 A.I. Cuza Str.)

8:30–9:00 Coffee

9:00–10:40 Short Lectures, Sessions A and B

Session A (Mihai I Hall)

Chair: Aurelian CERNEA

9:00–9:20 **Sanda MICULA**, *A superconvergent spline collocation method for mixed Volterra–Fredholm integral equations of the Hammerstein type* (p. 13)

9:20–9:40 **Adrian PETRUŞEL**, *Multi-valued Feng-Liu contractions and applications* (p. 15)

9:40–10:00 **Marcel-Adrian ŞERBAN**, *A global implicit operator theorem in terms of monotone operators* (p. 17)

10:00–10:20 **Aaron MELMAN**, *Angular distribution of zeros of polynomials whose coefficients exhibit specific sign patterns* (p. 13)

10:20–10:40 **Radu PĂLTĂNEA**, *On approximation of unbounded functions on non-compact intervals* (p. 15)

Session B (Room 444)

Chair: Sorin MICU

9:00–9:20 **Marilena CIONTESCU**, *Interval-valued optimal control problems and associated variational control inequalities* (p. 9)

9:20–9:40 **Vasile DRĂGAN**, *On the stochastic linear quadratic optimal control problem by piecewise constant controls. The infinite horizon time case* (p. 9)

9:40–10:00 **Sebastian ANIŢA**, *Predators as a possible strategy for controlling an epidemic* (p. 7)

10:00–10:20 **Laurenţiu-Emanuel TEMEREANCĂ**, *The approximation of the controls for the wave equation with a lower rate numerical vanishing viscosity* (p. 18)

10:20–10:40 **Cristina-Mihaela CEBUC**, *Optimization problems governed by approximately star-shaped functionals* (p. 8)

10:40–11:20 Coffee Break

11:20–12:20 Short Lectures, Sessions A and B

Session A (Mihai I Hall)

Chair: Sanda MICULA

11:20–11:40 **Vasile LUPULESCU**, *Inner product on the space of convex and compact sets* (p. 12)

11:40–12:00 **Gabriel PRĂJITURĂ**, *Recurrence in linear dynamics* (p. 16)

12:00–12:20 **George POPESCU**, *Perturbations of Rhaly operators* (p. 16)

Session B (Room 444)

Chair: Adriana BUICĂ

11:20–11:40 **Radu PRECUP**, *Localization of solutions for semilinear problems with poly-Laplace type operators* (p. 16)

11:40–12:00 **Vladimir RĂSVAN**, *On the challenge of critical cases in certain applications described by 1D partial differential equations of hyperbolic type* (p. 17)

12:00–12:20 **Gheorghe MOROŞANU**, *Second-order differential inclusions with two small parameters* (p. 14)

13:00–14:30 Lunch (University Restaurant)

15:00–17:00 Short Lectures, Sessions A and B

Session A (Mihai I Hall)

Chair: Radu PRECUP

15:00–15:20 **Denisa STANCU-DUMITRU**, *A minimization problem related to the principal frequency of the p-Bilaplacian with coupled Dirichlet-Neumann boundary conditions* (p. 18)

15:20–15:40 **Nataliia KOLUN**, *Energy-based localization of positive solutions for stationary Kirchhoff type equations* (p. 12)

15:40–16:00 **Cristian CAZACU**, *The Hardy inequality and asymptotic behavior of the heat equation on* $\mathbb{R}^{N-k} \times (0,\infty)^k$ (p. 7)

16:00–16:20 **Maria FĂRCĂŞEANU**, *Radial solutions for nonlinear elliptic equations with singular potentials* (p. 11)

16:20–16:40 **Nicolae LUPA**, *A semigroup approach for generalized dichotomies of evolution families* (p. 12)

16:40–17:00 **Andrei GRECU**, *The torsion problem of the p-Bilaplacian* (p. 11)

Session B (Room 444)

Chair: Adrian PETRUŞEL

15:00–15:20 **Aurelian CERNEA**, *Existence results for solutions of a Caputo-Fabrizio fractional differential inclusion with anti-periodic boundary conditions* (p. 8)

15:20–15:40 **Adrian VIOREL**, *On the robustness of economic growth models to perturbation* (p. 19)

15:40–16:00 **Serban VLAD**, *Defining the semimodularity of the Boolean asynchronous systems* (p. 19)

16:00–16:20 **Raluca EFREM**, *Stability and bifurcation analysis of an epidemic model* (p. 10)

16:20–16:40 **Luminiţa GRECU**, *Shape parameters influence of some radial basis functions on solution of singular boundary integral equation of the compressible fluid flow around obstacles* (p. 11)

16:40–17:00 **Florian MUNTEANU**, *On the Jacobi stability of a modified SIR epidemic pattern with demography* (p. 14)

17:00–17:30 Coffee Break

18:00–20:00 Gala Dinner (University Restaurant)