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Συντονιστές: Δ. Γκιντίδης, Γ. Καραλή, Ι. Καραφύλλης

Ομιλητές

Δέσποινα Αβραμίδου (Δημοκρίτειο Πανεπιστήμιο Θράκης)

On a close-to-cyclic system of max difference equations

In this paper we consider a close-to-cyclic system of two max difference equations. The study focuses on how the system's parameters and positive initial conditions influence the behavior of this system, such as the existence of an equilibrium, convergence properties and boundedness solutions. Illustrative examples are included to demonstrate the applicability of the results.

Ιωάννης Δελημπαλταδάκης (TU Eindhoven)

Feedback Optimization with State Constraints through Control Barrier Functions

Recently, there has been a surge of research on a class of methods called feedback optimization. These are methods to steer the state of a control system to an equilibrium that arises as the solution of an optimization problem. Despite the growing literature on the topic, the important problem of enforcing state constraints at all times remains unaddressed. In this talk, I present the first feedback-optimization method that enforces state constraints. The method combines a class of dynamics called safe gradient flows with high-order control barrier functions. I provide a number of results on the proposed dynamics, including well-posedness guarantees, anytime constraint-satisfaction guarantees, equivalence between the closed-loop's equilibria and the optimization problem's critical points, and asymptotic stability of optima.

Γεώργιος Δομαζάκης (Durham University)

Mean Field Games with jumps for non-separable Hamiltonians in displacement monotone regime

In this talk, we will discuss the existence and uniqueness of Nash equilibria for a Mean Field Game (MFG) system driven by a (possibly degenerate) mixed type of idiosyncratic noises, including both Brownian motion and jump diffusion, within the framework of displacement monotonicity. We establish the existence of MFG equilibria using a classical Schauder fixed-point argument, without relying on ellipticity conditions or (fractional) regularity arguments. We then address the uniqueness of the solution by employing a stochastic control approach, described through the associated forward-backward stochastic differential equation (FBSDE) formulation. Our results extend the corresponding results on displacement monotone setting to the case of Lévy–Itô jump diffusions.

The talk is based on a joint work with A. R. Mészáros (Durham).

Διονύσιος Θεοδόσης (Εθνικό Μετσόβιο Πολυτεχνείο)

Global Existence and Uniqueness of Solutions for a Nonlocal Age-Structured Chemostat Model

In this work we study an age-structured chemostat model with a nonlocal (renewal) boundary condition and a coupled substrate equation. The model is nonlinear and consists of a hyperbolic partial differential equation and an ordinary differential equation with a nonlocal term. Both differential equations contain a non-negative control input, while the states of the model are required to be positive. Under an appropriate weak solution framework, we define the state space and the input space for this model. We prove global existence and uniqueness of solutions for all admissible initial conditions and all allowable control inputs. To this purpose we employ a combination of Banach's fixed-point theorem with implicit solution formulas and useful solution estimates. Finally, we show that the age-structured chemostat model gives a well-defined control system on a metric space.

The talk is based on joint work with I. Karafyllis and M. Krstic.

Κωνσταντίνος Καλημέρης (Ακαδημία Αθηνών)

New solutions and aspects of evolution equations

In this talk we consider initial-boundary value problems (IBVPs) for linear evolution partial differential equations (PDEs) with time-dependent coefficients. We present (for the first time) integral representations of solutions for a big family of these problems; the derivation of these solutions is based on extensions of the unified transform (UT). Based on these solutions we discuss the well-posedness of these IBVPs for certain linear and non-linear PDEs. Finally, we show that, for certain evolution partial PDEs, the solution of IBVPs on a finite interval can be reconstructed as a superposition of solutions to two associated IBVPs posed on the half-line, which provides a completely new perspective on studying this large class of problems.

This is joint work with T. Ozsari and D. Mantzavinos.

Κωνσταντίνος Κουμάτος (University of Sussex)

Quasimonotone stresses in solid and fluid mechanics

Quasimonotonicity is a mean monotonicity condition for multidimensional systems establishing existence of weak solutions for non-variational, divergence form elliptic PDEs. Similar conditions have been utilised in the theory of the Navier-Stokes equations, also resulting in the existence of weak solutions. In this talk, we show a Gårding inequality for quasimonotone stresses and use it to prove weak-strong uniqueness results in the dynamic theory of viscoelasticity as well as the Navier-Stokes equations. In particular, for viscoelastic solids, we propose quasimonotone stresses as a candidate class for viscous stresses compatible with frame-indifference.

This is joint work with Myrto Galanopoulou (University of Sussex, UK) and Judith Camos-Cordero (UNAM, Mexico).

Νικόλαος Λαδάς

On minimum, comparison principles and the well-posedness for semilinear nonlocal RDEs

We consider second-order linear parabolic partial differential inequalities that include nonlocal zeroth-order quantities. For these, we demonstrate minimum principles that highlight the interplay between the regularity of their coefficients, the growth/decay rate of their solutions

and the integrability of the nonlocal interaction terms. Subsequently we utilize these minimum principles to establish comparison principles for related semilinear integrodifferential inequalities. We illustrate these principles via their relation to nonlocal reaction–diffusion equations and note their applicability for obtaining the well-posedness of associated Cauchy problems.

Λεωνίδας Μηνδρινός (Γεωπονικό Πανεπιστήμιο Αθηνών)

Direct and inverse problems in linear elasticity: The inhomogeneous case

his work explores direct and inverse problems using volume integral equations within the framework of linear, isotropic plane strain elasticity. In the static case, we extend Eshelby's inclusion method to obtain an integro-differential equation for the eigenstrain that admits a unique solution. For the time-harmonic elastodynamic problem, the boundary value problem is transformed into a Lippmann–Schwinger-type integral equation. Then, we examine the inverse problem to recover the elastic properties of an inclusion from the far-field pattern of the scattered field, produced by a limited set of incident waves. The Fréchet derivative of the forward mapping is derived, leading to a linearized far-field equation that is solved using a regularized Newton-based scheme. Numerical results are presented to illustrate the effectiveness of the proposed methodology.

This is a joint work with D. Gintides (NTUA, Greece).

Νικόλαος Παλληκαράκης (Εθνικό Μετσόβιο Πολυτεχνείο)

A Transmission Eigenvalues in Spherically Symmetric Media: From Theory to NSBF Computation

The transmission eigenvalue problem (TEP) is a fundamental topic in inverse scattering theory with applications to determining material properties from farfield measurements. We present an overview of the interior TEP for spherically symmetric refractive indices, discussing the existence and distribution of eigenvalues (real and complex) and key uniqueness results for the inverse problem, from the late 1980s to the present.

We then introduce a Neumann Series of Bessel Functions (NSBF) methodology for solving both the direct and inverse TEP. Via a Liouville transformation, we expand the characteristic function in a NSBF and compute eigenvalues through root-finding on truncated partial sums. For the inverse problem, we recover the refractive index from spectral data using NSBF-based techniques, with numerical examples demonstrating robustness and accuracy.

This is a joint work with Vladislav V. Kravchenko and L. Estefania Murcia-Lozano.

Κωνσταντίνος Παπαφιτσώρος (Queen Mary University of London)

A Descent Algorithm for the Optimal Control of ReLU Neural Network Informed PDEs Based on Approximate Directional Derivatives

We propose and analyse a numerical algorithm for solving a class of optimal control problems for learning-informed semilinear partial differential equations (PDEs). Such PDEs contain constituents that are in principle unknown and are approximated by nonsmooth ReLU neural networks. We first show that direct smoothing of the ReLU network with the aim of using classical numerical solvers can have disadvantages, such as potentially introducing multiple solutions for the corresponding PDE. This motivates us to devise a numerical algorithm that treats directly the nonsmooth optimal control problem, by employing a descent algorithm based on

approximate derivatives. We discuss the convergence properties of the algorithm and provide related numerical results.

Παναγιώτης Πατρινός (KU Leuven)

A generalized convexity perspective on nonlinearly preconditioned gradient methods

We present a unifying framework for recent gradient-based optimization algorithms widely used in large-scale settings, such as large language model training, grounded in the concept of Φ-convexity. Our analysis is streamlined, based only on fundamental principles, and leads to new insights and tighter convergence guarantees. We specialize to nonlinearly preconditioned gradient methods which encapsulate popular methods for neural network training including the gradient clipping and normalized gradient methods, thus providing a strong theoretical justification. This allows us to go beyond traditional Lipschitz smoothness assumptions that might be too restrictive in practice for modern applications and obtain proper convergence guarantees for wider classes of problems while also leading to new fast algorithms. Finally, we study nonlinearly preconditioned gradient flow as a continuous-time counterpart, highlighting its connection to doubly nonlinear equations and formulating it as the solution to an optimal control problem.

Joint work with Konstantinos Oikonomidis.

Ιωάννης Σγουραλής (University of Tennessee Knoxville)

Χαμιλτονιακές μέθοδοι στην ανάλυση φασματοσκοπικών δεδομένων

Η συνεστιακή φασματοσκοπία αποτελεί μια εξειδικευμένη πειραματική τεχνική που χρησιμοποιείται για τη μελέτη της κίνησης μεμονωμένων μορίων. Ωστόσο, η άμεση ανάλυση δεδομένων από συνεστιακή φασματοσκοπία παραμένει ένα ανοιχτό πρόβλημα, λόγω της τυχαίας κίνησης των μορίων, του θορύβου κατά την ανίχνευση και του μεγάλου όγκου των μετρήσεων. Στην παρούσα εργασία παρουσιάζω μια νέα μέθοδο ανάλυσης δεδομένων που αντιμετωπίζει αυτούς τους περιορισμούς.

Η προτεινόμενη μέθοδος αξιοποιεί στατιστικά μοντέλα και βασίζεται σε Χαμιλτονιακούς αλγορίθμους Monte Carlo, οι οποίοι οδηγούν την επίλυση διαφορικών εξισώσεων με περιοριστικές συνθήκες σταθερότητας κατά την αριθμητική ολοκλήρωσή τους. Αριθμητικές προσομοιώσεις δείχνουν ότι, με κατάλληλες τροποποιήσεις, η μέθοδος μπορεί να αναλύσει επιτυχώς πειραματικά φασματοσκοπικά δεδομένα με ρεαλιστικά χαρακτηριστικά.

Αλεξάνδρα Σταυριανίδη (University of Münster)

On the density of the supremum of solutions to a class of nonlinear SPDEs

The existence and regularity of the density of the supremum of stochastic processes has historically attracted significant interest. Classical results of Florit and Nualart provide general criteria ensuring the smoothness of the density of the sup of Gaussian processes, with applications to the Brownian sheet (Florit and Nualart, 1995) and fractional Brownian motion (Lanjri Zadi and Nualart, 2003). More recently, Dalang and Pu obtained quantitative bounds on the density of the supremum of the linear stochastic heat equation, linking these estimates to hitting probabilities (Dalang and Pu, 2018). In this talk, I will present recent work that establishes the existence of a density for the supremum of solutions to a class of nonlinear SPDEs in one spatial dimension, driven by space–time white noise and involving higher-order spatial diffusion. Our

approach uses Malliavin calculus and yields, to our knowledge, the first result on the density of the supremum for nonlinear SPDEs.

Κυριάκος Στρατουράς (Εθνικό Μετσόβιο Πολυτεχνείο)

Μοναδικότητα για το αντίστροφο φασματικό πρόβλημα για τμηματικά συνεχείς δείκτες διάθλασης

Το αντικείμενο μελέτης είναι το ζήτημα της μοναδικότητας στην ειδική περίπτωση όπου ο δείκτης διάθλασης είναι μια τμηματικά συνεχής και σφαιρικά συμμετρική συνάρτηση. Το ευθύ πρόβλημα έχει την ιδιαιτερότητα ότι η φασματική παράμετρος εμφανίζεται μόνο στη μια εκ των δύο διαφορικών εξισώσεων του συστήματος, η οποία είναι τύπου Helmholtz και αντιστοιχεί σε ένα τεχνητό μεταϋλικό. Αποδεικνύουμε ότι μια ιδιοτιμή από κάθε χαρακτηριστική συνάρτηση, οι οποίες προκύπτουν έπειτα από εφαρμογή της μεθόδου χωρισμού μεταβλητών, αρκεί για τον καθορισμό ενός πηλίκου δεδομένων Cauchy των ιδιοσυναρτήσεων στο σύνορο. Αυτή η πληροφορία για κάθε χαρακτηριστική, προσδιορίζει το χάρτη Dirichlet-to-Neumann για την εξίσωση του Helmholtz που αντιστοιχεί σε ένα υλικό που χαρακτηρίζεται από τον δείκτη διάθλασης $n(r)$. Εφαρμόζοντας κάποια αποτελέσματα από τη θεωρία Borg-Levinson για την εξίσωση του Schrödinger, προκύπτει το θεώρημα μοναδικότητας για τον δείκτη διάθλασης. Επιπρόσθετα, παρουσιάζουμε μια τεχνική για την ταξινόμηση των ιδιοτιμών στις αντίστοιχες χαρακτηριστικές και κάποια αναλυτικά παραδείγματα τμηματικά σταθερών δεικτών με ένα σημείο άλματος και την ανακατασκευή τους από από κάποιες ιδιοτιμές.

Κοινή εργασία με τον Δρόσο Γκιντίδη.

Κωνσταντίνος Τζιράκης (Πανεπιστήμιο Κρήτης)

The FitzHugh-Nagumo System on cylindrical surfaces: symmetrization and effective system

In this talk, I will present recent results on the FitzHugh-Nagumo (FHN) system of partial differential equations. We consider the FHN system in a more realistic geometric setting: on cylindrical surfaces of variable radii, rather than straight lines without internal geometric structure, as it has been extensively done. We show that, under some reasonable conditions, the solutions of the system are exponentially approximated by their radial averages. We also show that the radial averages are close, for very long times, to solutions of a 1-spatial-dimensional system involving the cylindrical profile: it is obtained from the standard FHN system by replacing the second-order derivative by the radial surface Laplace-Beltrami operator. This system is considerably simpler for mathematical analysis and numerical simulations. It offers an effective system for the pulse propagation. I will outline the analytical approach to obtain the above results, and, time permitting, I will discuss interesting related open problems and natural extensions of these results. The talk is based on the recent joint work with Israel Michael Sigal (University of Toronto, Canada) and Georgia Karali (NKUA, Greece).

Σπυρίδων Φίλιππας (University of Helsinki)

On the stability of a hyperbolic inverse problem

The Boundary Control method is one of the main techniques in the theory of inverse problems. It allows to recover the metric or the potential of a wave equation in a Riemannian manifold from its Dirichlet to Neumann map (or variants) under very general geometric assumptions. In this talk we will address the issue of obtaining stability estimates for the recovery of a potential in some specific situations. As it turns out, this problem is related to the study of

the blow-up of quantities coming from control theory and unique continuation. This is based on joints works with Lauri Oksanen.