BOOK OF ABSTRACTS

SS1 - Sharp Energy Decay and Stabilization in Dissipative Evolution Equations: From Waves to Fluids

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SS1

On the Stability of Coupled Wave Equations with Local Kelvin-Voigt Damping and Non-Smooth Coefficients

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In this talk we discuss the stability of a coupled wave system with localized damping. The model consists of two coupled wave equations with a Kelvin-Voigt damping acting in one equation and a localized frictional damping acting in the other. The Kelvin-Voigt damping coefficient presents a singularity at the interface of the damped and undamped regions. Under these conditions, we prove a polynomial stability result.

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Recent results on thermo-elasticity for beams

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In recent years, increasing attention has been turned to the analysis of some classical engineering structures describing the dynamics of linear and nonlinear vibrations of beams.

In the literature, the mechanical properties and the global analysis of the longtime dynamics of axially loaded single beams and of elastically connected double-beam systems were first analyzed within the Euler–Bernoulli theory, also according to the nonlinear Woinowsky–Krieger model [1]. As it is well known, the Euler–Bernoulli beam model wholly ignores the shearing deformation and rotational inertia effects. These limitations require a better-adapted beam model, such as the Timoshenko theory, which seems to have a wider range of applicability and to be physically more realistic since it better captures the behavior of the system [2]. The Timoshenko model is obtained in the particular case where the longitudinal displacement is not considered and by supposing zero initial curvature; thus, it can be generalized by the Bresse system, the governing model for arched beams [3]. These distinct models will be investigated in the context of single and double beams with different dissipative mechanisms in order to obtain their stabilization.

A rigorous mathematical investigation of these beam configurations requires, as a fundamental step, a comprehensive analysis of their well-posedness and long-time dynamics [4-6].

Well-posedness, meaning the existence, uniqueness, and regularity of the solutions, can be established by implementing advanced functional analysis techniques, such as the semigroup theory of linear operators for linear problems, or the Faedo–Galerkin approximation scheme combined with energy methods for nonlinear models.

The asymptotic behavior of the thermoelastic and viscoelastic structures as time tends to infinity is investigated by tracking the evolution of the total energy functional. A crucial aspect of this qualitative analysis is to identify the precise rates of energy dissipation. Specifically, it is interesting to determine the exact structural or physical conditions, such as the equality of wave propagation speeds or the geometric coupling coefficients, that trigger a rapid exponential decay of the solutions.

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Viscoelastic Effects on Thermal Convection in Jeffreys Fluids

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We investigate the stability and stabilization properties of a non-isothermal Jeffreys fluid occupying a horizontal layer and subject to a constant vertical throughflow. The model is formulated within the Boussinesq approximation and combines buoyancy-driven convection with viscoelastic memory effects, leading to a dissipative evolution system for the velocity, temperature, and memory variables. The constitutive setting is consistent with the classical theory of viscoelastic fluids with memory developed by Joseph [1,2].

The analysis concerns the stability of the basic throughflow state from both linear and nonlinear viewpoints. A normal-mode analysis yields the critical conditions for the onset of instability and shows that viscoelastic memory may promote oscillatory bifurcations, while the imposed throughflow has a marked stabilizing effect on the basic configuration. To complement the spectral analysis, we develop an energy method and derive global stability conditions in terms of suitable Lyapunov-type functionals, obtaining exponential decay of perturbations below explicit threshold values of the Rayleigh number.

Particular attention is devoted to the interplay between the throughflow parameter and the viscoelastic coefficients governing memory and relaxation. The comparison between linear and nonlinear thresholds clarifies how elastic effects modify the dissipative mechanism and the size of the stability region with respect to the Newtonian case. These results contribute to the mathematical understanding of stabilization phenomena in thermally driven viscoelastic flows and fit naturally within the theory of dissipative evolution equations with memory.

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Critical wave equation with nonlinear $E(t)u_t$ damping

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We investigate a semilinear wave equation with energy-critical nonlinearity and a nonlinear damping mechanism driven by the total energy of the system. The model combines the quintic defocusing term with a time-dependent dissipation of the form $E(t)u_t$, which introduces a non-standard feedback structure coupling the dynamics and the energy functional. Weak solutions are constructed via Galerkin approximations, with the passage to the limit relying on uniform energy estimates and compactness arguments. Special attention is devoted to the critical nature of the nonlinearity, where concentration phenomena prevent purely energy-based methods from yielding refined spacetime control. This difficulty is resolved by incorporating nonhomogeneous Strichartz estimates together with smoothly truncated spectral approximations, ensuring uniform bounds at the dispersive level. Finally, we establish polynomial decay rates for the energy by adapting Nakao's method to the present nonlinear dissipative framework. The results highlight the stabilizing effect of the energy-dependent damping and its interaction with the critical wave dynamics.

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A porous thermoelastic problem with microtemperatures and fading memory

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In this talk, we will present the study, from the numerical point of view, of a porous thermoelastic problem with microtemperatures, where the thermal evolution is influenced by the history of both the temperature and microtemperatures [1]. This leads to a coupled system of partial integro-differential equations. Then, fully discrete approximations will provided by using the implicit Euler scheme and the finite element method. Some numerical issues as the discrete stability and an a priori error analysis will be discussed, and the linear convergence of the approximations will be concluded for a suitable additional regularity. Finally, we will show some one-dimensional numerical examples to demonstrate the numerical convergence and the behavior of the discrete energy.

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A mixed peridynamic theory for beams

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In this talk, we introduce a new model for beam-type equations, driven by a mixed operator which is the sum of the classical biharmonic operator with a regional fractional Laplacian. The novelty is the peridynamical approach: the Dirichlet conditions hold in an extended outer domain (the horizon), which describes well the fact that a floor in reinforce concrete is stuck in the wall. We will present the spectral properties of this operator, studying stationary and evolution problems associated to it. Some open problems will be presented as weill.

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INSENSITIZING CONTROLS WITH $N-1$ COMPONENTS FOR THE N−DIMENSIONAL LADYZHENSKAYA–SMAGORINSKY SYSTEM

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Abstract
This article deals with a Ladyzhenskaya–Smagorinsky type differential turbulence model with partially known initial data. We are interested in the existence of insensitive controls, with $N-1$ scalar controls in an arbitrary control domain, for the local L^2 norm of the solution of model, that is, the goal is to find a control function, having one vanishing component, such that some functional of the state is locally insensitive to the perturbations of these initial data. In this system, we find local and nonlocal nonlinearities, with the usual transport terms and a turbulent viscosity, respectively. Such a problem can be reduced to a non-standard null controllability problem, of a nonlinear cascade system governed by an equation forward in time and one backward. We use a known null controllability result, with controls having one vanishing component, for a linear problem and prove some technical lemmas. The key point to establish the null controllability for the nonlinear cascade system is to use an inverse mapping theorem in infinite-dimensional spaces.

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Resonant Secondary Instabilities and Oscillatory Dynamics in Nonlinear Diffusion Systems

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Stability and destabilization of coherent structures are fundamental issues in the analysis of evolutionary partial differential equations. In reaction-diffusion systems with nonlinear diffusion, including chemotactic [6] and cross-diffusion effects [4, 5], stationary Turing patterns may undergo secondary instabilities that are neither associated with classical Hopf or wave bifurcations nor induced by external periodic forcing. Instead, they arise from resonant interactions between the fundamental Turing mode and its spatial subharmonics, ultimately leading to stable oscillatory dynamics.

More precisely, through nonlinear mode interactions, $1:2$ and $3:2$ resonances activate the subharmonic modes with wavenumber $k_c/2$ and $3k_c/2$. Their interaction with the fundamental Turing mode destabilizes the stationary pattern, giving rise to stable spatially heterogeneous states that are periodic in time.

While this instability framework is well known in fluid dynamics [1, 3, 7], its counterpart in reaction–diffusion systems remains comparatively underexplored.

To characterize quantitatively the onset of these secondary instabilities, we first identify the codimension-two points at which the Turing mode and one of its spatial subharmonics become simultaneously critical. A center-unstable manifold reduction [2] then yields the normal form governing the resonant amplitudes. The resulting amplitude equations determine the stability of the Turing branch, predict the critical threshold for the onset of oscillatory dynamics, and explain the underlying instability mechanism.

The bifurcation structure and dynamical behavior predicted by the amplitude equations are in very good qualitative and quantitative agreement with numerical simulations of both the full reaction–diffusion system and its Galerkin truncations.

Finally, the reduced dynamics reveal that the resonant secondary instability organizes the transition from stationary patterns to increasingly complex spatio-temporal behavior. As the bifurcation parameter increases, a cascade of bifurcations ultimately leads to spatio-temporal chaos.

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