LIST OF ABSTRACTS

On the control of coupled systems of PDE's and the insensitizing control of the scalar wave equations

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Abstract. We shall present some challenges for the controllability of coupled systems by a reduced number of controls together with recent results on this subject and applications to the existence of insensitizing locally distributed or boundary controls for the scalar wave equation.

Singular gradient flow of the distance function and homotopy equivalence

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Abstract. Let M be a riemannian manifold and let Ω be a bounded open subset of M. It is well known that significant information about the geometry of Ω is encoded into the properties of the distance, $d_{artial\Omega}$, from the boundary of Ω. Here, we show that the generalized gradient flow associated with the distance preserves singularities, that is, if x_0 is a singular point of $d_{artial\Omega}$ then the generalized characteristic starting at x_0 stays singular for all times. As an application, we deduce that the singular set of $d_{artial\Omega}$ has the same homotopy type as Ω.

Joint work with P. Cannarsa, Khai T. Nguyen and C.Sinestrari.

Stabilization by switching control methods

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Abstract. In this talk we consider some stabilization problems for the wave equation with switching. We prove exponential stability results for appropriate damping coefficients. The proof of the main results is based on D'Alembert formula and some energy estimates.

Compactness estimates for hyperbolic conservation laws

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Abstract. We analyze the compactness in L^1_{loc} of the semigroup $(S_t)_{t\geq 0}$ of entropy weak solutions to convex conservation laws in one space dimension. In particular, relying on a controllability type result, we establish lower compactness estimates on the Kolmogorov's entropy of the image through S_t of bounded sets in $L^1 \cap L^\infty$. Next, we discuss the extension of these results to the case of convex balance laws.

Controllability and Lipschitz stability for Grushin-type operators

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Abstract. The Baouendi-Grushin operator is an important example of a degenerate elliptic operator that has strong connections with almost-riemannian structures. It is also the infinitesimal

generator of a strongly continuous semigroup on Lebesgue spaces with very interesting properties from the point of view of control theory. Such properties will be discussed in this lecture, starting with approximate and null controllability for parabolic control systems associated with Grushin-type operators on a bounded two-dimensional domain. We will then address the inverse source problem for these operators deriving a Lipschitz stability result.

Borg-Levinson type theorem with partial spectral data

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Abstract. My talk is on a recent joint work with Plamen Stefanov in which we prove a stability estimate related to the multi-dimensional Borg-Levinson theorem of determining a potential from spectral data: the Dirichlet eigenvalues λ_k and the normal derivatives $\partial\phi_k/\partial\nu$ of the eigenfunctions on the boundary of a bounded domain. The estimate is of Hölder type, and we allow finitely many eigenvalues and normal derivatives to be unknown. We also show that if the spectral data is known asymptotically only, up to $O(k^{-\alpha})$ with $\alpha \gg 1$, then we still have Hölder stability.

Linear and nonlinear parabolic equations: two different approaches for the reconstruction of several coefficients

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Abstract. In this talk I am interested to give an overview of recent results concerning the reconstruction of one or several coefficients associated to linear and non linear parabolic equations. The main goal is to obtain these results minimizing the observations. The first results (see [1] and [2]), involve Carleman inequalities and give Lipschitz stability results, but a measurement of the solution of the system on all the domain is necessary. The last results (see [3] and [4]) avoid this constraint and concern uniqueness results via pointwise measurements : e.g. reconstruction of all the n coefficients $(\mu_k(x))_{k=1,n}$ in the following equation :

$$\frac{\partial u}{\partial t} = D\frac{\partial^2 u}{\partial x^2} + \sum_{k=1}^{N} \mu_k(x)\, u^k + g(x,u),\ \text{for } t>0,\ x\in(a,b),$$

basing ourselves on n pointwise measurements. In this work, the use of the initial condition $u_0 = u(0,\cdot)$ is a partial answer to a longstanding open problem.

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Perturbation method for inverse problems and its application to control theory

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Abstract. We are concerned with an inverse problem for a linear evolution equation of the firstorder. Both hyperbolic and parabolic cases will be considered. A complete second-order evolution equation will be considered. We indicate sufficient conditions for existence and uniqueness of a solution. All the results apply well to inverse problems for equations from mathematical physics. As a possible application of the abstract theorems, some examples of partial differential equations are given.

We also provide some applications to important equations from Control Theory.

Global Wellposedness for Reaction-Diffusion Systems with Boundary Diffusion, Bounded Total Mass, and Finite Time Blowup

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We consider reaction-diffusion systems of the form

$$\frac{\partial u_i}{\partial t} = d_i \Delta u_i + F_i(u_1, ..., u_n)$$

for $i = 1, ..., n$. This system can be written in the abstract form

$$du/dt = Au + B(u)$$

where the partial differential equation $du/dt = Au$ models the diffusion and the ordintary differential equation $dw/dt = B(w)$ models the chemical reactions. This simple model has been amazingly effective in describing physical phenomena observed in problems from science and engineering. Some recent applications in chemical engineering required dynamic boundary conditions and diffusion along the spatial boundary in order to accurately model the physical situation. In many of these applications $u_i(x, t)$ represents a mass density for one of the components, and

$$\|u(\cdot, t)\|_{L^1} = \sum_i \|u_i(\cdot, t)\|_1$$

is bounded independently of the time; yet the quantity

$$\|u(\cdot, t)\|_\infty$$

blows up in finite time. A natural question is: Does the (local) solution extend to a global in time weak solution? Sometimes yes and sometimes no. The proof of global wellposedness can be reduced to showing that the corresponding linear diffusion semigroup (corresponding to the operator A) is compact on the appropriate L^1-type space. In these problems the appropriate L^1-type space is the space X_1 introduced by Favini-Goldstein-Goldstein-Romanelli; X_1 requires appropriate weights in the boundary integral portion of the norm. In this talk we will explain the solution of this problem in a quite general context. This problem is of independent interest since it solves a problem of Agmon, Douglis and Nirenberg from 1959. The work presented is joint with Jerry Goldstein (University of Memphis) and Michel Pierre (École Normale Supérieure de Cachan).

Energy related results for wave equations with strong damping

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Abstract. Of concern are the asymptotics for

$$u''(t) + Bu'(t) + Au(t) = 0, \quad t > 0,$$

where A, B are commuting positive selfadjoint operators on a complex Hilbert space H with A unbounded. The usual (abstract) wave equation is when $B = 0$. The case of $B = bI$ with b a positive constant refers to the telegraph equation. Strong damping means that B is unbounded (and B is smaller than A in some sense). Of concern are several types of results, including asymptotic equipartition of energy, when the ratio of kinetic to potential energy has limit 1 as t goes to infinity. Other issues include overdamping and asymptotic parabolicity. My collaborators on the recent results in these areas are Ted Clarke, Genni Fragnelli, Gisele Goldstein, Gustavo Perla, Guillermo Reyes, and Silvia Romanelli.

Indirect stabilization of evolution equations in Hilbert space

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Abstract. In recent years, the interest of the scientific community in the stabilization and control of systems of partial differential equations has remarkably increased, due to the fact that such systems arise in several applied mathematical models, such as those used for studying the vibrations of flexible structures and networks, or fluids and fluid-structure interactions. Moreover, it becomes essential to study whether controlling only a reduced number of state variables suffices to ensure the stability of the full system.

For this reason, we investigate stability properties of indirectly damped systems of evolution equations in Hilbert spaces, under new compatibility assumptions. We prove polynomial decay for the energy of solutions and optimize our results by interpolation techniques, obtaining a full range of power-like decay rates. In particular, we give explicit estimates with respect to the initial data. We discuss several applications to hyperbolic systems with *hybrid* boundary conditions and globally distributed coupling, including the system of two wave equations subject to Dirichlet and Robin type boundary conditions, respectively.

Moreover, we present some new results concerning the stabilization properties of systems of weakly coupled hyperbolic equations with both damping and coupling acting only on a subset of the boundary.

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Linear mixed parabolic problems with dynamic boundary conditions

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Abstract. We consider abstract parabolic systems of the form

$$\begin{cases} D_t u(t,x) - D_x^2 u(t,x) + Au(t,x) = f(t,x), & t \in (0,T), x \in \mathbb{R}^+, \\ D_t u(t,0) - D_x u(t,0) + Bu(t,0) = h(t), & t \in (0,T), \\ u(0,x) = u_0(x), & x \in \mathbb{R}^+. \end{cases}$$

A is the infinitesimal generator of an analytic semigroup, B is the infinitesimal generator of a strongly continuous semigroup, commuting with A in the sense of the resolvent. Moreover, $D(A^{1/2}) \subseteq D(B)$. We prove results of maximal regularity in an L^p setting.

Increasing stability of the continuation for Helmholtz type equations

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Abstract. We obtain estimates for solutions of the Cauchy problem for general elliptic partial differential equations of second order of the Helmholtz type (i.e. containing high frequency term k^2u. Under a priori bounds on a suitably introduced high frequency part of a solution we derive a Lipschitz bound on the low frequency part with an additional term which decays when k grows. Proofs use some commutator estimates for special pseudo-differential differential operators (low frequency projectors) and energy estimates for hyperbolic equations. These estimates show that unstable (high frequency) part of the solution is decreasing when k grows, and hence stability of the continuation is increasing.

Inverse problems for nonlinear microstructured solids

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Abstract. We consider some nonlinear models of microstructure in the form of higher-order PDE-s or systems of PDE. We formulate theorems for the existence of solitary waves in these models. Further, we pose inverse problems to determine coefficients of the PDE-s that use measurements of the solitary waves. We formulate theorems of uniqueness for the inverse problems and present numerical examples.

Linear-quadratic regulator with intermediate points for degenerate equations with unbounded operator

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Abstract. We study linear-quadratic optimal control problems in a Hilbert space where the state equation is unsolvable with respect to the derivative and contains an unbounded operator.

The performance index is the sum of the integral of a quadratic form with respect to the control and the state variable on a finite or infinite time interval and also quadratic forms with respect to the differences between the state variable values at fixed points and given values.

The optimal control is presented in the feedback form using the implicit differential operator Riccati equation for finite regulation time or the operator equation of the Riccati type with a special symmetry condition for the solution in the case of infinite time. The minimal value of the minimized functional is calculated. Some illustrative examples are also given.

This is joint work with Angelo Favini.

Strongly ill-posed problems for differential and integro-differential evolution equations

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Abstract. The talk will be concerned with a few ill-posed problems related to evolution equations with no initial condition(s), but endowed with a global Dirichlet condition, i.e. on the whole of the lateral boundary $(0,T)\times\partial\Omega$, and a local Neumann condition, i.e. on $(0,T)\times\Gamma$, Γ being *any open* subset of $\partial\Omega$.

The basic questions to be answered will be uniqueness of the solution and its continuous dependence in usual Sobolev spaces. The fundamental tool will consist of Carleman estimates.

For such problems, involving both differential and integro-differential equations, some identification problems will be dealt with, concerning uniqueness of the solution and its continuous dependence. Such identification problems will be concerned with recovering both constants and functions. In some cases these problems can be reduced to non-standard and non-causal strongly ill-posed integro-differential problems.

An overview on nonautonomous Kolmogorov equations

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Abstract. In this talk we report on some recent results for evolution operators associated with nondegenerate nonautonomous elliptic operators with unbounded coefficients defined in i$I\times R^N$ where I is a right-halfline.

Existence to Time-Dependent Nonlinear Diffusion Equations via Convex Optimization

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Abstract. In this paper we provide new existence results for time-dependent nonlinear diffusion equations by following a variational principle. More specifically, the nonlinear equation is reduced to a convex optimization problem via the Lagrange-Fenchel duality relations. We prove that in the case when the potential related to the diffusivity function is continuous and has a polynomial growth with respect to the solution the optimization problem is equivalent with the original diffusion equation. In the situation when the potential is singular the minimization problem has a solution which can be viewed as a generalized solution to the diffusion equation. In this case it is proved however that the null minimizer in the optimization problem in which

the state boundedness is considered in addition is the weak solution to the original diffusion problem. This technique allows to prove existence in the cases when standard methods do not apply.

Stochastic problems for Gelfand–Shilov systems

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Abstract. We consider the stochastic Cauchy problem for the Gelfand–Shilov systems as a particular case of the abstract problem $X'(t) = AX(t) + W(t),\ t \geq 0,\ X(0) = \xi$, with A generating regularized semigroups in Hilbert spaces H and with H-valued white noise perturbation W. The problem is ill-posed through the irregular behavior of white noise process $W(t), t \geq 0$, and properties of semigroups generated by A : solution operators to the corresponding homogeneous problem being defined on H may be discontinuous or be defined not on the whole space [1–2].

Solutions to the problem generalized in time, random, spacial and cumulative variables are constructed. Special attention will be paid

• to the semigroups generated by differential operators $A = P(i\frac{\partial}{\partial x})$ in the case of Petrovskii well-posed and conditionally well-posed systems,

• to relations of abstract (stochastic) distribution spaces with Gelfand–Shilov and Ivanov generalized function spaces and setting the problem in the spaces.

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Unique continuation, continuous dependence and approximation results for severely ill-posed integro-differential parabolic problems

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Abstract. The results presented here are just devoted to shed some light on the less studied subject concerning integro-differential linear equations, mainly on the questions of uniqueness and continuous dependence on the data, two fundamental topics for people working in Applied Mathematics.

More exactly, we will deal here with an integro-differential linear parabolic problem, where the integral operators entering the equation are of Volterra type with respect to time. In our problem *no* initial condition will be supplied. It will be replaced by the requirement that the “temperature” v should have a *prescribed profile* $v(t, x) = g(t, x)$ for a.e. $(t, x) \in (0, T) \times \omega$, ω being a subdomain of the spatial domain Ω where the parabolic equation is assigned.

We will deal with integro-differential equations of form

$$D_t v(t,x) - A(t,x,D)v(t,x) = f(t,x) - \int_0^t h_0(t,x,s)v(s,x)\,ds$$
$$+ \int_0^t \sum_{j=1}^d h_j(t,x,s)D_{x_j}v(s,x)\,ds, \quad \text{for a.e. } (t,x) \in (0,T)\times\Omega. \tag{1}$$

We stress that equations (1), with $h_1,\ldots,h_d = 0$, occur in the linear theory of heat flow in a rigid body consisting of a material with thermal memory when the internal energy is described by

$$e(v)(t,x) = \int_0^t h(t,x,s)v(s,x)\,ds,$$

and the heat flux with memory is assumed to be missing. We note that the term corresponding to $e(v)$ entering the balance equation is actually

$$D_t e(v)(t,x) = h(t,x,t)v(t,x) + \int_0^t D_t h(t,x,s)v(s,x)\,ds.$$

Consequently our equation (1) takes into account also this physical case.
Our main task consists in estimating u in $C((0,T];L^2(\Omega)) \cap L^2_{\mathrm{loc}}((0,T];H^1(\Omega))$ in terms of suitable norms of the data as well as in showing that the *unique continuation property* holds for our ill-posed problem.
The fundamental tool to give some positive answer to our problem will be derived by adapting to our case the celebrated Carleman estimates for PDE's - of use both in Control and Inverse Problem Theory -.
Then we consider integro-differential equations of form

$$D_t u(t,x) - A_0(t,x,D)\Big[u(t,x) + \int_0^t k_0(t,x,s)u(s,x)\,ds\Big]$$
$$+ \sum_{j=1}^d a_j(t,x)D_{x_j}u(t,x) + a(t,x)u(t,x) + \int_0^t k_1(t,x,s)u(s,x)\,ds$$
$$+ \int_0^t \sum_{j=1}^d k_{2,j}(t,x,s)D_{x_j}u(s,x)\,ds = f(t,x), \quad \text{for a.e. } (t,x) \in (0,T)\times\Omega. \tag{2}$$

Also in this case we study a problem in which *no* initial condition will be supplied. It will be replaced by the requirement that the "temperature" u should have a *prescribed profile* $u(t,x) = g_0(t,x)$ for a.e. $(t,x) \in (0,T)\times\omega$, ω being a subdomain of the spatial domain Ω where the parabolic equation is assigned.
We stress that equations (2) occur in the linear theory of heat flow in a rigid body consisting of a material with thermal memory when the heat flux is governed by

$$q(u) = c(x)\cdot\nabla_x u(t,x) + \int_0^t k_2(t,x,s)\cdot\nabla_x u(s,x)\,ds.$$

Consequently our equation takes into account also this physical case.
Our main task consists first in showing that the *unique continuation property* holds for our ill-posed problem and then in estimating u in $C((0,T_0];L^2(\Omega)) \cap L^2_{\mathrm{loc}}((0,T],H^1(\Omega))$, $T_0 \in (0,T)$, in terms of suitable norms of the data and some *a priori* bound in $H^1((0,T_0);L^2(\Omega))$ of the solution itself on a small time interval $(0,T_0)$.
We stress that the previous results concerning the simpler equation (2) are the starting point to treat the present more complex case.

On spectral inequalities for the control of linear PDEs: Schrödinger group versus heat semigroup

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Abstract. Some spectral inequalities were introduced in control theory by David Russell and George Weiss in 1994 as an infinite-dimensional version of the Hautus test for controllability. They are an efficient tool for the control of the linear Schrödinger equation in arbitrary time from a localized source term as proved by Nicolas Burq and Maciej Zworski in 2004 using the unitarity of the Fourier transform in Hilbert spaces. They also allow to analyze which filtering scale is sufficient to discretize this equation in space, as initiated by Sylvain Ervedoza in 2008.

A parallel approach to the control of the linear heat equation in arbitrary time from a localized source term has developed. It starts from another type of spectral inequality introduced by Gilles Lebeau in the late 90s and follows the strategy devised in 1995 by Lebeau and Robbiano. This talk will connect these two spectral approaches, compare the control of the Schrödinger group and the heat semigroup at the level of abstract functional analysis, and illustrate this with examples of PDE problems.

This is a joint work with Thomas Duyckaerts from the Université Paris 13, France.

The main reference for this talk is our preprint available for download: *Resolvent conditions for the control of parabolic equations*, `http://hal.archives-ouvertes.fr/hal-00620870`.

Subsidiary references are my two previous papers (also available at the same URL): *A direct Lebeau-Robbiano strategy for the observability of heat-like semigroups*, Discrete Contin. Dyn. Syst. B **14** (2010), no. 4, 1465–1485, and *Resolvent conditions for the control of unitary groups and their approximations*, J. Spectr. Theory **2** (2012), no. 1, 1–55.

Some generalizations of the Cahn-Hilliard equation

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Abstract. Our aim in this talk is to discuss a Cahn-Hilliard model with a proliferation term which has, e.g., applications in biology. In particular, we will discuss the asymptotic behavior of the system in terms of finite-dimensional attractors.

Recovering the reaction and the diffusion coefficients in a linear parabolic equation

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Abstract. Let H be a real separable Hilbert space and $A : \mathcal{D}(A) \to H$ be a positive and self-adjoint (unbounded) operator. We consider the identification problem consisting in searching for a H-valued function u and a couple of real numbers λ and μ, the first one being positive, that fulfill the initial-value problem

$$u'(t) + \lambda\, Au(t) = \mu\, u(t), \quad t \in (0,T), \quad u(0) = u_0,$$

and the additional constraints

$$\|A^{r/2}u(T)\|^2 = \varphi \quad \text{and} \quad \|A^{s/2}u(T)\|^2 = \psi,$$

for some time-instant $T > 0$, where we denote by A^s and A^r the powers of A with exponents $r < s$. Provided that the given data u_0 and φ, $\psi > 0$ satisfy proper *a priori* limitations, using a Faedo-Galerkin approximation scheme we construct a unique solution (u, λ, μ) on the whole interval $[0, T]$, and exhibit an explicit continuous dependence estimate - of Lipschitz-type - with respect to the data. Also, we provide specific applications to second and fourth-order parabolic initial-boundary value problems.

We finally recall that the problem of recovering one single constant in the same equation from a final overdetermination of the above type have been successfully studied in [1] (in collaboration with A. Lorenzi) and in [2].

References

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A simple approach to the Cauchy problem for complex Ginzburg-Landau equations by compactness methods

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Abstract. This talk is concerned with the Cauchy problem (CGL) in $L^2(\mathbb{R}^N)$ for complex Ginzburg-Landau equations with Laplacian Δ and nonlinear term $|u|^{q-2}u$ multiplied by the complex coefficients $\lambda + i\alpha$ and $\kappa + i\beta$, respectively ($q \geq 2$, $\lambda > 0$, $\kappa > 0$, $\alpha, \beta \in \mathbb{R}$). The global existence of strong solutions to (CGL) is established without any upper restriction on $q \geq 2$ but with some restriction on α/λ and β/κ. The result corresponds to Ginibre-Velo [1, Proposition 5.1] which is technically proved by combining convolution (regularizing) methods with compactness (localizing) methods, while our proof here is fairly simplified. The key to our proof is the Cauchy problem $(\text{CGL})_R$ which is (CGL) with Δ replaced with $\Delta - V_R$, where $V_R(x) := (|x| - R)^2$ ($|x| > R$), $V_R(x) := 0$ ($|x| \leq R$). The solvability of $(\text{CGL})_R$ is a direct consequence of Okazawa-Yokota [2, Theorem 4.1]. Taking the limit of global strong solutions to $(\text{CGL})_R$ as $R \to \infty$ yields a global strong solution to (CGL). The result gives also an unbounded version of [2, Theorem 1.1 with $p = 2$] for the initial-boundary value problem on bounded domains.

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This is a joint work with Philippe Clément (Delft University of Technology), Motohiro Sobajima and Tomomi Yokota (Tokyo University of Science).

Linear Operator Inequality and Null Controllability with Vanishing Energy for boundary control systems

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Abstract. We consider a linear boundary control system on a Hilbert space H which is null controllable at some time $T_0 > 0$. Parabolic and hyperbolic PDEs provide several examples of such systems and are included in our treatment. To every initial state $y_0 \in H$ we associate the minimal "energy" needed to transfer y_0 to 0 in a time $T \geq T_0$ ("energy" of a control being the square of its L^2 norm). Clearly, it decreases with the control time T. We shall prove that, under suitable spectral properties of the linear system operator, the minimal energy converges to 0 for $T \to +\infty$. This extends to boundary control systems a property known for distributed systems (see [Priola-Zabczyk, Siam J. Control Optim. 42 (2003)] where the notion of "null controllability with vanishing energy" is introduced).

The proofs in the cited paper depend on properties of the Riccati equation which are not available in the general setting which we study here. For this reason we shall proceed in two steps: first we prove that NCVE is equivalent to a suitable version of Yakubovich-Popov problem. We are so reduced to give conditions under which the infimum of this Yakubovich-Popov problem is equal zero. These conditions are given in the second step, using properties of the Linear Operator Inequality (LOI). Use of LOI allows us to slightly weaken the assumptions in the cited previous paper.

This paper has been written jointly with E. Priola and J. Zabczyk.

Asymptotic stability of second–order evolution equations with intermittent delay

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Abstract. We consider second–order evolution equations with intermittently delayed/not–delayed damping and give sufficient conditions ensuring asymptotic and exponential stability results. Our abstract framework is then applied to the wave equation, the elasticity system and the Petrovsky system.

Joint work with S. Nicaise.

Geometric Aspects of Harnack Inequalities for Degenerate Partial Differential Equations

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Abstract. Harnack's inequality is a fundamental tool in Potential Theory. For instance, it is used in the Perron method to prove the local uniform convergence of any bounded increasing sequence of harmonic functions. Harnack type inequalities for general elliptic and parabolic equations are used to prove regularity results for weak solutions, and to find accurate asymptotic estimates for positive solutions.

Some geometric features appear when considering second order Partial Differential Equations in the form $X_1^2 u + \cdots + X_m^2 u + X_0 u = 0$, where $X_0, \ldots, X_m$ are Hörmander's vector fields in $\mathbb{R}^N$. We discuss about the geometric aspects of of the Harnack type inequalities for the above Partial Differential Equations, and we will give some applications.

Wentsell uniformly elliptic operators in general domains

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Abstract. We consider Wentzell uniformly elliptic (symmetric or nonsymmetric) operators on spaces of L^p-type, $1 \leq p < \infty$, which incorporate both the underlying (general) domain and its boundary. The main aim will be to examine wellposedness and regularity results for the associated (C_0) semigroups.

Source identification in a Semilinear Evolution Delay Equation

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Abstract. We prove the existence, uniqueness and continuous dependence on the data of a mild solution to an identification problem for a first-order semilinear delay differential equation in a Banach space subjected to an additional constraint expressed by means of an integral. Two applications to some identification problems, the first one for a parabolic delay equation and the second one for a hyperbolic delay equation, are also considered.
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