Universität Konstanz

Workshop on Partial Differential Equations
Petropólis, Rio de Janeiro

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Konstanzer Schriften in Mathematik und Informatik
Nr. 70, September 1998

ISSN 1430–3558

Workshop on Partial Differential Equations
Petrópolis, Rio de Janeiro

March 16-20, 1998

Abstracts*

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70/1998

Universität Konstanz

Fakultät für Mathematik und Informatik

*Received until May 23, 1998

Preface

From March 16 until March 20, 1998, the international "Workshop on Partial Differential Equations" took place in Petrópolis, Rio de Janeiro. About 50 participants from Brazil, China, France, Germany, Italy, Peru, Russia and the USA had the opportunity to benefit from talks on a variety of topics in Partial Differential Equations, focussing on subjects from thermo- and viscoelasticity.

The idea of a workshop — arising out of the collaboration of the organizers based on a Brazil-German agreement on scientific-technological cooperation — could be realized in connection with the creation of the new site of the LNCC (Laboratório Nacional de Computação Científica) in Petrópolis. The organizers thank[†] the sponsoring institutions LNCC and FINEP for their support and in particular the LNCC and its staff for the local support and the hospitality.

Jaime E. Muñoz Rivera, Petrópolis
Reinhard Racke, Konstanz

September 1998

[†]Partial support from CNPq-DLR for R. Racke is gratefully acknowledged.

Workshop on Partial Differential Equations

LNCC - Petrópolis, Rio de Janeiro

March 16-20, 1998

Program

Monday, March 16

Chairman: Jaime E. Muñoz Rivera

09:00 .- **Registration.**

10:00 .- *Opening.*

11:00 .- *Coffee Break*

11:25 .- **Michael Renardy.** *Virginia Polytech Institute & State University*

High Weissenberg number asymptotics and reentrant corner singularities for viscoelastic fluids

12:25 .- **André Nachbin.** *Instituto de Matemática Pura e Aplicada. IMPA*

On the apparent diffusion of water waves propagating in disordered channels

13:25 .- *Lunch*

Chairman: Marco Antônio Raupp

15:25 .- **Felipe Linares.** *Instituto de Matemática Pura e Aplicada. IMPA*

Global well posedness for the modified KdV equation

16:25 .- **Hermano Frid Neto.** *Universidade Federal de Rio de Janeiro*

Asymptotic behavior of solutions of certain multi-d viscous systems of conservation laws

17:25 .- **Clodoaldo Ragazzo.** *Universidade de São Paulo*

Buckling of long rods in the presence of a flat obstacle

17:45 .- *Coffee Break*

18:10 .- **Marcelo Martins dos Santos.** *Universidade de Campinas*

Godunov scheme for conservations laws with boundary conditions: Traces and boundary layers

– 18:30

Tuesday, March 17

Chairman: Vanilde Bisognin

09:00 .- **Songmu Zheng.** *Fudan University*

Asymptotic Behaviour of solution to a system of nonlinear PDE arising from the study of phase transitions in shape memory alloys

10:00 .- **Orlando Lopes.** *Universidade de Campinas*

Radial symmetry of minimizers in the case of vanishing constraint

11:00 .- *Coffee Break*

11:25 .- **Claudio Giorgi.** *University of Brescia*

Exponential stability in linear heat conduction with memory. A semigroup approach.

12:25 .- **Vittorino Pata.** *University of Brescia*

Asymptotic behavior and uniform attractor for a semilinear heat equation with memory

12:45 .- *Lunch*

Chairman: Orlando Lopes

14:45 .- **Marcio Murad.** *Laboratório Nacional de Computação Científica*

Recent advances in asymptotic analysis of multiscale poroelasticity

15:45 .- **Eleni Bisognin.** *Universidade Federal de Santa Maria*

Attractor for nonlinear elastic wave equation

16:05 .- **Vladimir Shelukhin.** *IM-UFRJ*

Bingham compressible plastic equations

16:25 .- *Coffee Break*

16:50 .- **Ma To Fu.** *Universidade Estadual de Maringá.*

Remarks on transmission problems

17:10 .- **Edson Lueders.** *Universidade Estadual de Londrina*

Regularizing properties of systems of Schrödinger equations

17:30 .- **Juan Soriano.** *Universidade Estadual de Maringá*

Existence and boundary stabilization of a nonlinear hyperbolic equation with time-dependent coefficients

17:50 .- **Vanilde Bisognin.** *Universidade Federal de Santa Maria.*

Uniform stabilization and space periodic solution of a nonlinear dispersive system

– 18:10

Wednesday, March 18

Chairman: Nikolai Lar'kin

09:00 .- **Irena Lasiecka.** *University of Virginia*

Analyticity and stability of semigroups arising in thermoelastic plates with free boundary conditions

10:00 .- **Assia Benabdallah.** *University of Besançon*

Dynamical stabilization and applications to various thermoelastic models

11:00 .- *Coffee Break*

11:25 .- **Mario Davila.** *Universidade Federal de São Juan del Rei*

Sobre sistemas de equações tipo KdV: Algumas variantes

Thursday, March 19

Chairman: Gustavo Perla Menzala

09:00 .- **Stuart Antman.** *University of Maryland*

Nonlinear problems of viscoelasticity of strain-rate type

10:00 .- **Helena Lopes.** *Universidade de Campinas*

On a class of stationary 2D incompressible flows with very singular vorticity

11:00 .- *Coffee Break*

11:25 .- **Luci Harue Fatori.** *Universidade Estadual de Londrina*

Asymptotic behavior for thermoelastic systems with memeory

11:45 .- **Jorge Hounie.** *Universidade Federal de São Carlos*

The similarity principle for compex vector fields

12:45 .- *Lunch*

Chairman: Helena Lopes

14:45 .- **Abimael Loula.** *Laboratório Nacional de Computaçao Científica* Numerical analysis for thermally coupled problems

15:15 .- **Raúl Feijóo.** *Laboratório Nacional de Computaçao Científica*

Shape optimization in frictionless contact problems

15:45 .- **Felix P. Quispe Gomez.** *Instituto Tecnológico de Aeronautica*

Estabilidade e controle de sistemas hiperbolicos com coeficientes discontinuos

16:05 .- **Juan Limaco Ferrel.** *Universidade Federal Fluminense*

Sistema Thermoelástico linear em dominios não cilindrico

16:25 .- *Coffee Break*

16:50 .- **Ademir Pazoto.** *Universidade Federal de Rio de Janeiro*

Exponential stability for a 1-D nonlinear Timoshenko's model with thermal effects

17:10 .- **Eduardo Arbieto Alarcon.** *Universidade Federal de Santa Catarina.*

Existence of the global attractor for a nonlinear dissipative evolution equation

17:30 .- **Doherty Andrade.** *Universidade Estadual de Maringa - LNCC*

Exponential decay for a nonlinear wave equation with a viscoelastic boundary condition

17:50 .- **R. Doria.** *Universidade Católica de Petrópolis*

Lightweb

– 18:10

Friday, March 20

Chairman: Djairo Guedes de Figueiredo

09:00 .- **Zhuangyi Liu.** *University of Minnesota-Duluth*

Semigroup properties of linear thermoelastic and viscoelastic systems

10:00 .- **Gustavo Perla Menzala.** *Laboratório Nacional de Computação Científica*

On the weak limit of 1-D dynamical nonlinear von Kármán model

11:00 .- *Coffee Break*

Chairman: Reinhard Racke

11:25 .- **Djairo Guedes de Figueiredo.** *UNICAMP*

The generalized spectrum of the Laplacian

12:25 .- *Lunch*

14:00 .- **Nikolai Lar'kin.** *Universidade Estadual de Maringá*

Global solutions of the carrier equation with nonlinear damping

15:00 .- **Boris Kapitonov.** *Sobolev Institute of Mathematics*

Simultaneous exact controllability of evolution systems

16:00 .- *The End*

Abstracts

Nonlinear problems of viscoelasticity of strain-rate type

Stuart S. Antman
University of Maryland

This lecture treats various quasilinear parabolic-hyperbolic systems that describe the behavior of nonlinearly viscoelastic solids, emphasizing the technical difficulties caused by the requirement that the equations capture important mechanical effects. Particular attention is devoted to the role of viscosity in preventing total compression, to the asymptotics associated with small density, and to Hopf bifurcation problems.

Dynamical stabilization and applications to thermoelasticity models

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1 Motivation and Introduction

We consider a basic system represented in the form :

$$u' = Au + Bv \tag{1}$$

Our aim is to find *dynamical stabilizers* for this system. We mean by this that v will satisfy an equation

$$Ev' = Du + Cv$$

such that the obtained coupled system

$$\begin{cases} u' = Au + Bv \\ Ev' = Du + Cv \end{cases} \tag{2}$$

is exponentially stable. These questions occur in the field of *Smart Materials* in that we have to find new materials which contain their own stabilizers. The concept of *dynamical stabilizer* has been introduced by the automaticians in the finite dimensional case (ordinary differential equations).

As we are motivated by *Smart materials* we restrict ourselves to elastic basic systems

$$\begin{aligned} w'' &= -Aw + h \\ h &= B_0 w' + B_1 w + B_2 z \\ z' &= -Dz + C_1 w + C_2 w' \end{aligned}$$

We consider two different types of *Indirect Damping*: the *velocity coupled dissipator* and the *displacement coupled dissipator*. The first one corresponds to setting

$$B_0 = B_1 = 0, \quad B_2 = B, \quad C_1 = 0, \quad C_2 = -B^*$$

and it is referred to as "*thermoelastic systems*" and the second

$$\begin{pmatrix} w'' \\ z'' \end{pmatrix} + E \begin{pmatrix} 0 \\ z' \end{pmatrix} = \begin{pmatrix} -A & B \\ B^* & -D \end{pmatrix} \begin{pmatrix} w \\ z \end{pmatrix} \text{ on } H \times G \tag{3}$$

and it is referred to as "*elastic systems*".

2 The results

In this lecture we give results on sufficient and sometimes necessary conditions on the operators A, B, D, E such that the energy of the coupled system decays to zero exponentially as time goes to infinity and apply these general results to particular thermoelastic models. We also compare, by decoupling techniques, these dynamical feedbacks with static feedbacks. We end by giving additional properties of these coupled systems (analyticity...)

Global attractor for the nonlinear elastic waves equation

E. Bisognin
Faculdades Fraciscanas, Santa Maria-RS-Brazil

Introduction: The objective of this work is to study the existence and dimension of the global attractor for the nonlinear waves equation

$$u_{tt} - b^2\Delta u - (a^2 - b^2)grad(divu) + |u_t|^2 u_t = f$$

where $x \in \Omega \subset R^3, \Omega$ an open bounded set of R^3 with smooth boundary $\partial\Omega$, and $t \geq 0$.

We assume that the medium is isotropic, that is, the elastic properties are the same in all directions. The displacement field at time t of a particle , which at the nondeformed state has coordinates $x = (x_1, x_2, x_3)$, is given by $u(x,t) = (u^1(x,t), u^2(x,t), u^3(x,t))$ and satisfies the system above. In this system a and b are real constants with $a > b > 0$ which are connected with the Lamé constants, and f is an external force.

The existence of global solution is proved by using semigroup theory and, using a-priori estimates we prove the existence of absorbing set for the semigroup.

The existence of the universal (weak) attractor for the semigroup $S(t)$ and its dimension is proved following the same ideas of Temam[4].

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Asymptotic behavior of periodic solutions to dissipative system of BBM's type

VANILDE BISOGNIN
Faculdades Fraciscanas, Santa Maria-RS-Brazil

Introduction

We consider a nonlinear dispersive system of coupled equations of Benjamin-Bona-Mahony's type under the effectes of dissipation. The model take the form:

$$
\begin{aligned}
Mu_t + a_1 Rv_t + uu_x + a_2 vv_x + a_3(uv)_x + \alpha Lu &= 0 \\
Mv_t + a_1 Ru_t + vv_x + a_2 uu_x + a_3(uv)_x + \alpha Lv &= 0
\end{aligned}
$$

where $a_{1,}a_2, a_3, \alpha$ are real constants with $\alpha > 0$ and $a_1 > 0, u = u(x,t), v = v(x,t)$ are real valued functions.

The operators $M, R,$and L can be differential or pseudo-differential operators and they characterize the dispersive and dissipative properties of the medium.

The aim of this work is to study the dacay, in time, of solutions of the space-periodic problem.We show that this decay is exactly of exponential type and it is characterized by an eigenvalue of the dissipation operator.

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Sobre sistemas de equações tipo KdV: Algumas variantes

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We study the conservation laws of a coupled system of equations of KdV type derived by Gear-Grimshaw in 1984. They found two conservation laws for the system and Bona-Ponce-Saut-Tom derived a third conservation law in 1992. In this work, it is shown that if the constants of the system satisfy some conditions then there are an infinite number of conservation laws, which can be derived in the same form as Miura-Kruskal-Gardner derived the infinite conservation laws of the KdV equation. Some applications are presented.

Asymptotic behaviour of thermoelastic systems of memory type

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Jaime E. Muñoz Rivera
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Department of Research and Development, Petrópolis, RJ, Brazil

In this work we study the one-dimensional linear thermoelastic hyperbolic system with memory on heat conduction and Dirichlet boundary conditions. We show that the first order energy of the system decays exponentially to zero as time goes to infinity if we assume that the memory kernel is a regular function, decays expontentially for large time and is sufficient small at the origin.

Key words: thermoelasticity, exponential decay, memory kernel.

The Fucik spectrum

Djairo G. de Figueiredo
Universidade de Campinas

Let us consider the p-Laplacian $\Delta_p u = div(|\nabla u|^{p-2}\nabla u)$, for $1 < p < \infty$ acting on functions defined in a bounded domain Ω of R^N, $N \geq 1$. The Fucik spectrum of $-\Delta_p$ on $W_0^{1,p}(\Omega)$ is defined as the set Σ_p of the $(\alpha, \beta) \in R^2$ such that

$$-\Delta_p u = \alpha(u^+)^{p-1} - \beta(u^-)^{p-1} \text{ in } \Omega,\ u = 0 \text{ on } \partial\Omega$$

has a nontrivial solution u. The usual spectrum corresponds to $\alpha = \beta$. Denoting by $\lambda_1 < \lambda_2$ the two first eigenvalues of $-\Delta_p$ on $W_0^{1,p}(\Omega)$ (Cf [1], [9]), it is clear that Σ_p contains, in particular, (λ_1, λ_1), (λ_2, λ_2), and the two lines $\lambda_1 \times I\!R$ and $I\!R \times \lambda_1$. Several papers have treated the spectrum in the case $p = 2$. For instance ([3], [5], [6], [2], [8], [10]). In the quasilinear case $p \neq 2$, only the case $p = 1$ seems to have been considered in some extent, cf [7]. He shows that Σ_p has the same general shape of the unidimensional case for $p = 2$: that is, a sequence of hyperbola type curves.

In [4] we study the spectrum Σ_p in the general case, $1 < p < \infty$ and $n \geq 1$. We construct a nontrivial curve in Σ_p. This construction differs entirely of the one we used in the case of $p = 2$, where we minimized certain functional on associated manifolds, cf [2]. In the quasilinear case, we make recourse to the Mountain Pass Theorem applied to functionals defined in certain manifolds, which are only C^1. This very lower regularity poses several difficulties. The interest in the Fucik spectrum resides in its use in the analysis of Boundary value problems of the type

$$-\Delta_p u = f(x, u) \text{ in } \Omega \text{ and } u = 0 \text{ on } \partial\Omega.$$

Here the spectrum has to do with some sort of Palais-Smale condition when one treats the the problem by variational methods. If one uses topological methods, the spectrum interferes with the existence of a priori bounds.

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On the asymptotic behavior of solutions of certain multi-D viscous systems of conservation laws

Hermano Frid

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We present a recent result establishing the asymptotic stability of planar Riemann solutions for certain systems of viscous conservation laws in several space variables. The systems to which our result applies are those whose flux fields are endowed with a common coordinate structure of Riemann invariants whose level sets are hyperplanes. No smallness restrictions are necessary, neither on the Riemann data nor on the perturbations.

1991*Mathematics Subject Classification.Primary*: 35B40,35B35;Secondary:35L65,35K55
Keywords and phrases.
Conservation laws, Riemann problems, asymptotic stability, multidimensional systems.
Research supported by CNPq, proc.352871/96-2.

Exponential stability for linear problems in heat conduction with memory: a semigroup approach

Claudio Giorgi

Università di Brescia - Italy

We consider a class of differential systems describing temperature evolution in a rigid, isotropic, homogeneous heat conductor obeying a heat flux law with linear memory.

$$\partial_t\vartheta(t)+\alpha_0\vartheta(t)-\int_{-\infty}^{t}\alpha(t-\tau)\vartheta(\tau)\,d\tau-k_0\Delta\vartheta(t)-\int_{-\infty}^{t}k(t-\tau)\Delta\vartheta(\tau)\,d\tau=r.$$

Introducing $\Theta(t)=\int_0^t\vartheta(s)\,ds$ and the *summed temperature history*

$$\eta^t(s)=\int_0^s\vartheta^t(\tau)\,d\tau=\Theta(t)-\Theta(t-s)\ ,\qquad t\geq s\geq 0,$$

as new variables, the original problem can be transformed into the autonomous system

$$\begin{aligned}&\partial_t\vartheta(t)=k_0\Delta\vartheta(t)-\alpha_0\vartheta(t)+k_\infty\Delta\Theta(t)+\int_0^\infty\mu(s)\Delta\eta^t(s)\,ds-\int_0^\infty\nu(s)\eta^t(s)\,ds+r\\&\partial_t\Theta(t)=\vartheta(t)\\&\partial_t\eta^t(s)=\vartheta(t)-\partial_s\eta^t(s)\end{aligned}$$

where $\mu(s)=-k'(s)$, $\nu(s)=\alpha'(s)$ and $k_\infty=k(\infty)$. Thereby, we re-cast the heat-flux equation in the *semigroup framework* along the same procedure followed by C.M.Dafermos (1970) in his pioneer work on exponential stability in linear viscoelasticity.

• The choice $k_0>0$ and $\alpha_0=0$, leads to a model close to the theory proposed by *Coleman & Gurtin* (1967). It exhibits a behavior not far from that of a *"strongly damped wave equation"*. Indeed, in the limit case when $\mu\,,\nu\equiv 0$ we have

$$\partial_{tt}\Theta(t)=k_0\Delta\partial_t\Theta(t)+k_\infty\Delta\Theta(t)+r.$$

• When $k_0=0$ and $k(0)=\int_0^\infty\mu(s)\,ds>0$, the model is derived in the framework of the *Gurtin & Pipkin*'s theory (1968). It is "hyperbolic" (perturbations propagate with *finite speed* $V\geq\sqrt{k(0)}$) and "weakly dissipative": when $\mu,\nu\equiv 0$ the *heat equation* turns into the *weakly damped wave equation*

$$\partial_{tt}\Theta(t)=-\alpha_0\partial_t\Theta(t)+k_\infty\Delta\Theta(t)+r$$

The case $k_\infty>0$ has been studied by Barbu. Under initial-history and Dirichlet-boundary conditions, we establish the *exponential stability* of solutions assuming $k_\infty=0$, $r=0$ and

$$\mu\,,\nu\in C^1\cap L^1\quad \mu\,,\nu\geq 0,\ \mu'\,,\nu'\leq 0\,,\ \mu'+\gamma\mu\leq 0\text{ and }\nu'+\delta\nu\leq 0.$$

If α_0 is positive, we use the energy method and Poincaré inequality; when it vanishes, the same result is established by means of the Lumer-Phillips theorem and a suitable Lemma on the exponential decay of a C_0-semigroup.

A generalized similarity principle for complex vector fields and applications

S. Berhanu

J. Hounie
National Laboratory for Scientific Computation
Department of Research and Development, Petrópolis, RJ, Brazil

P. Santiago

In this talk we consider first order equations of the form

$$Lw = Aw + B\overline{w} \tag{4}$$

where L belongs to a class of smooth, complex vector fields in the plane (see section 2) while A and B are bounded functions. Equation (1.1) is motivated by the classical elliptic equation

$$\frac{\partial w}{\partial \overline{z}} = Aw + B\overline{w} \tag{5}$$

which had been the subject of many works (see for example,[B1], [B2], [BN], [C], [R] and [V]). In the literature solutions of (1.2) are called pseudoanalytic functions or generalized analytic functions; they share many properties with analytic functions of a single complex variable. These properties follow from the Similarity Principle which is valid for solutions of (1.2). This principle says that every continuous solution w of (1.2) has the form $w = e^g h$, for some holomorphic function h and Hölder continuous g. Thus w and h are "similar" in the sense that both $\frac{w}{h}$ and $\frac{h}{w}$ are bounded away from zero on compact sets.

The Similarity Principle holds for any elliptic vector field L, since in appropriate coordinates, L becomes a multiple of $\frac{\partial}{\partial \overline{z}}$.

In a recent paper [M], the author explored the validity of the Similarity Principle for the following three nonelliptic vector fields:

$$L_1 = \frac{\partial}{\partial y} - 3iy^2\frac{\partial}{\partial x}, \quad L_2 = \frac{\partial}{\partial y} - ix\frac{\partial}{\partial x}, \quad \text{and} \quad M = \frac{\partial}{\partial y} - iy\frac{\partial}{\partial x}.$$

It is proved in [M] that the Similarity Principle is valid for L_1 and L_2 in the following sense: if w is a solution of $L_j w = Aw + B\overline{w} \quad (j = 1, 2)$, then w has the form $w = e^g h$, where $L_j h = 0$. It is also shown that the Similarity Principle fails for the Mizohata vector field M. The vector fields $\frac{\partial}{\partial \overline{z}}$, L_1 and L_2 are locally solvable while M is not.

We may prove a generalized similarity principle for solutions of (1.1) where L belongs to a class of locally solvable vector fields This result is applied to establish uniqueness in the Cauchy problem for semilinear equations

$$Lw = f(x, w),$$

where f is assumed to have bounded first derivatives and w is in L^p_{loc}, $p > 1$.

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S. Berhanu thanks IMPA of Brazil for an invitation to a pde workshop on July, 1998, that facilitated this work.

J. Hounie: Partially supported by CNPq, FAPESP and FINEP.

P. Santiago: Partially supported by CNPq.

Global solutions of the carrier equation with nonlinear damping

NIKOLAI LARKIN

Departamento de Matematica, Fundação Universidade Estadual de Maringa, Brazil

We prove the existence and uniqueness of global solutions to the mixed problem for the Carrier equation

$$u_{tt} - M\left(\int_{\Omega} u^2 dx\right)\Delta u + g(u_t) = f,$$

where $g'(s) \geq 0$, $0 < m_0 \leq M(\lambda)$ and no "'smallness"' conditions are imposed on the initital data. Moreover, the algebraic and exponential decays of the energy were proved.

Analyticity, stability and controllability of thermoelastic plates with free boundary conditions

Irena Lasiecka
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Questions related to stability, regularity and controllability of thermoelastic plates defined on a bounded, smooth domian $\Omega \subset R^2$ are considered. The governing equations written in a canonical form are:

$$w_{tt} - \gamma \Delta w_{tt} + \Delta^2 w + \Delta \theta = 0; \quad \theta_t - \Delta \theta - \Delta w_t = 0 \tag{6}$$

With the model (6) we associate Robin's boundary conditions imposed on the variable θ and various boundary conditions: clamped, hinged or free imposed on the mechanical variable w.

$$w = \nabla w = 0; \quad \textit{clamped.} \tag{7}$$

$$w = \Delta w + B_1 w + \theta = 0 \quad \textit{hinged.} \tag{8}$$

$$\Delta w + B_1 w + \theta = 0; \quad \frac{\partial}{\partial \nu} \Delta w + B_2 w - \gamma \frac{\partial}{\nu} w_{tt} + \frac{\partial}{\partial \nu} \theta = 0 \quad \textit{free.} \tag{9}$$

where the boundary opearators B_1, B_2 are given by:

$$B_1 w = (1 - \mu)[2\nu_2 \nu_2 w_{xy} - \nu_1^2 w_{yy} - \nu_2^2 w_{xx}];$$

$$B_2 w = \frac{\partial}{\partial \tau}(1 - \mu)[(\nu_1^2 - \nu_2^2) w_{xy} + \nu_1 \nu_2 (w_{yy} - w_{xx})]$$

The constant μ stands for Poisson's modulus, $\nu = (\nu_1, \nu_2)$ is an outward normal and τ stands for tangential vector.
The constant $\gamma \geq 0$ represents moments of inertia present in the model. The presence of this parameter in the equations has a strong effect on the character of dynamics. The main results presented include:

1. If $\gamma = 0$ the system (6) generates an analytic and uniformly stable semigroup for *all boundary conditions* listed in (2-4).

2. For $\gamma \geq 0$ the system (6) is exponentially stable for *all boundary conditions in (2-4)* . Moreover , in the case of *clamped or hinged* boundary conditions the decay rates are *independent on the parameter* $\gamma \geq 0$.

3. The system is exactly fully controllable (in both thermal and mechanical variable) with internal controls acting on the heat component *only*. This result holds for all $\gamma \geq 0$ and *all cases of boundary conditions.*

4. For the case of *free boundary conditions* and $\gamma > 0$, the system is exactly/approximately controllable with boundary controls (RHS of (4) is replaced by boundary controls). This is to say that it is exactly controllable in the mechanical variable and approximately controllable in the thermal variable.

From the PDE point of view, problems with *free* boundary conditions are closely related to propagation of "sharp" trace regularity available for hyperbolic like systems where Lopatinski conditions are not satisfied. This is caused by the fact that the free (rather than much simpler clamped or hinged) boundary conditions are imposed. We shall see how this propagation is responsible for the establishment of appropriate observability, regularity and stabilizability inequalities. This particular phenomena has no counterpart in the case of other boundary conditions considered (hinged or clamped), where Lopatinski conditions are naturally satisfied.

Semigroup properties of linear thermoelastic and viscoelastic system

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In this talk, we discuss the semigroup properties for linear thermoelastic and viscoelastic systems. Consider an abstract evolution equation

$$\begin{cases} \frac{dz}{dt} = \mathcal{A}z, & t \in [0, \infty) \\ z(0) = z_0 \end{cases}$$

on an Hilbert space H. Let $e^{\mathcal{A}t}$ be the associated c_0 semigroup of contractions. The asymptotic behavior and the regularity of the solution

$$z(t) = e^{\mathcal{A}t} z_0$$

are related to the exponential stability, diffentiability and analyticity of the semigroup. It is known that when the imaginary axis is in the resolvent set of $\mathcal{A}$,

1. $e^{\mathcal{A}t}$ is exponentially stable if and only if

$$\lim_{|\beta| \to +\infty} \|(i\beta I - \mathcal{A})^{-1}\|_H < \infty;$$

2. $e^{\mathcal{A}t}$ is analytic if and only if

$$\lim_{|\beta| \to +\infty} \||\beta|(i\beta I - \mathcal{A})^{-1}\|_H < \infty.$$

To check these necessary and sufficient conditions, we present a unified contradiction argument combined with frequency domain multiplier technique. Using this method, we obtain the exponential stability for the linear thermoelastic rod, the linear thermoelastic plate when the rotational inertia is included, as well as the viscoelastic solid when the memory kernel decays exponentially. We also obtain the analyticity for the linear thermoelastic plate when the rotational inertia is neglected.

Numerical analysis of thermally coupled problems

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We study two classes of thermally coupled problems. The first one is a creep problem consisting in finding the velocity $u : \Omega \to R^d$, the stress tensor $\sigma = \sigma^T, \sigma : \Omega \to R^d \times R^d$ and the temperature $\theta : \Omega \to R$ satisfying

$$\nabla \cdot \sigma = f, \quad \text{in } \Omega$$

$$A(\sigma, \theta) = \nabla u^s, \quad \text{in } \Omega$$

$$\nabla \cdot u = 0, \quad \text{in } \Omega$$

$$\rho c_p u . \nabla \theta - \kappa \Delta \theta = \sigma . \nabla u^s, \quad \text{in } \Omega$$

with homogeneous Dirichlet boundary conditions

$$u = 0, \quad \text{on } \Gamma = \partial \Omega$$

$$\theta = 0, \quad \text{on } \Gamma$$

and Ostwald-De-Waele and Arrhenius laws:

$$A(\sigma, \theta) = K e^{\frac{\beta}{\theta}} |\sigma_D|^{\zeta - 2} \sigma_D,$$

where

$$\sigma_D = \sigma - \frac{1}{2} \text{tr} \sigma I = \sigma - \frac{1}{2} p I .$$

The second one is a stationary thermistor problem consisting in finding the potential $u : \Omega \to I\!R$ and the temperature $\theta : \Omega \to I\!R$ satisfying

$$-\nabla \cdot (\mu(\theta) \nabla u) = f, \quad \text{in } \Omega$$

$$-\Delta \theta = \mu(\theta) |\nabla u|^2, \quad \text{in } \Omega$$

$$u = 0, \quad \text{on } \Gamma$$

$$\theta = 0, \quad \text{on } \Gamma .$$

Finite element approximations are introduced combined with iterative schemes to partially decouple the systems at each iteration. Numerical results are presented for both problems. Existence, uniqueness and regularity of the week solution, and H^1-error estimate are proved for the stationary thermistor problem.

Smoothing properties for systems of nonlinear Schrödinger equations

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We study the initial value problem associated to the following system of nonlinear Schrödinger equations

$$i\partial_t q = -\frac{1}{2}\triangle q + q^2 r + 2\alpha x_1 q$$

$$i\partial_t r = \frac{\lambda}{2}\triangle r - q r^2 - 2\alpha x_1 r$$

where λ, α are real constants, q and r are complex functions on $\boldsymbol{R}^n$ and x_1 is the first coordinate of the vector $x \in \boldsymbol{R}^n$. If $n = \lambda = 1$ and $\alpha = 0$ then the system belongs to the AKNS hierarchy of completely integrable hamiltonian systems and generalizes the cubic nonlinear Schrödinger equation. We show that the solutions exhibit smoothing properties which are related to the dispersive term. The gain in regularity is enhanced by the decay of the initial data at infinity and is measured by means of weighted Sobolev spaces. We establish local well-posedness in those spaces as well as in H^∞ and the Schwartz space of rapidly decreasing functions. Global well-posedness is proved for small initial data. The relation between decay and regularity is studied, and among other results we show that if the initial datum has compact support then the solution is a C^∞ function.

Remarks on a transmission problem

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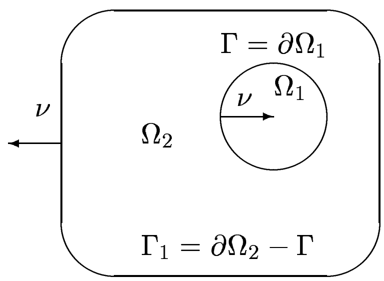
We study the following system of partial differential equations arising in transmission or interface problems:

$$
(*) \quad \begin{cases} -\Delta u = f(x,u) & \text{in} \quad \Omega_2 \\ -\Delta v = g(x,v) & \text{in} \quad \Omega_1 \\ u = v & \text{on} \quad \Gamma \\ \dfrac{\partial u}{\partial \nu} = \dfrac{\partial v}{\partial \nu} & \text{on} \quad \Gamma \\ v = 0 & \text{on} \quad \Gamma_1; \end{cases}
$$

where $\Omega \subset \mathbf{R}^n$ is given by two subdomains Ω_1 and Ω_2 having the following shape.



$\Omega = \Omega_1 \cup \Omega_2$

$\nu =$ exterior normal to Ω_2

Assuming that f and g are subcritical nonlinearities we obtain existence and regularity results by using of variational methods.

Recent advances in asymptotic analysis of multiscale poroelasticity

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Thermomechanical microstructural dual porosity models for swelling porous media incorporating coupled effects of hydration, heat transfer and mechanical deformation are proposed. The microscale consists of macromolecular structures (clay platelets, polymers, shales, biological tissues, gels) in a solvent (adsorbed water), both of which are considered as distinct nonoverlaying continua. These continua are homogenized to the meso (intermediate scale) in the spirit of hybrid mixture theory (HMT) so that at the mesoscale they may be thought of as two overlaying continua. Application of HMT leads to a two-scale model which incorporates coupled thermal and physico-chemical effects between the macromolecules and adsorbed solvent. Further, a three-scale model is obtained by homogenizing the particles (clusters consisting of macromolecules and adsorbed solvent) with the bulk solvent (solvent not within but next to the swelling particles). This yields a macroscopic microstructural model of dual porosity type. In the macroscopic swelling medium the mesoscale particles act as distributed sources/sinks of mass, momentum and energy to the macroscale bulk phase system. A modified Green's function method is used to reduce the dual porosity system to a single-porosity system with memory. The resultant theory provides a rigorous derivation of creep phenomena which are due to delayed intra-particle drainage (e.g. secondary consolidation of clay soils). In addition, the model reproduces the classical theory of poroelasticity upon neglection of the physicochemical effects. Furthermore, error estimates for spatially discrete Galerkin finite element approximations of the multiscale model are presented. The short and long time behaviors of such approximations based on both stable and unstable combinations of finite element spaces of displacement and pore pressure fields are discussed.

On the apparent diffusion of water waves propagating in disordered channels

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We are primarily interested in long-waves propagating in rough channels. When the bottom topography has an arbitrary rapidly varying profile, it is modeled as a stochastic process and we fall into the extensively studied area of wave propagation in random media. We develop a reflection-transmission theory based on the asymptotic analysis of stochastic differential equations. This theory accounts for general bottom profiles of large amplitude. Both monochromatic and pulse shaped waves are considered. Numerical experiments using Boundary Elements were carried out and the agreement between theory and computation is very good.

Our present goal is to verify if known results from potential theory persist in a more general model. To do so we use a hydrostatic Navier-Stokes model to reproduce the experiments performed with the Boundary Element code. The first set of experiments are very encouraging. We switch–off the viscosity and obtain results similar to the linear potential theory, when we use a small amplitude/depth ratio (i.e. linear regime).

Currently we are also studying the application of the O'Doherty–Anstey approximation to water waves, and on the diffusive upscaling of fine scale features of the topography.

Asymptotic behavior and uniform attractor for a semilinear heat equation with memory

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We consider the following nonautonomous differential system describing heat conduction with memory, which is derived in the framework of the Coleman & Gurtin model, introducing the temperature history $\eta^t(s)$ as a variable of the problem:

$$\partial_t\theta - k_0\Delta\theta - \int_0^\infty \mu(s)\Delta\eta^t(s)\,ds + g(\theta) = h$$
$$\partial_t\eta^t(x,s) = \theta(x,t) - \partial_s\eta^t(x,s)$$
$$\theta(\tau) = \theta_\tau, \qquad \eta^\tau(s) = \eta_\tau(s) \quad s > 0$$
+ Dirichlet boundary conditions.

The memory kernel μ is a differentiable, summable, positive nonincreasing function on $\mathbb{R}^+$, whereas the nonlinear term g satisfies certain growth conditions.
The above system can be transformed into a nonlinear nonautonomous differential equation in $\mathcal{H} = L^2 \times L^2_\mu(\mathbb{R}^+, H^1_0)$.

Main results are as follows.

• EXISTENCE AND UNIQUENESS. Given $h \in L^2_{loc}(\mathbb{R}, L^2)$, there exists a unique solution of the above equation, namely, there is a C_0-process $U_h(t,\tau)$ (depending on the "symbol" h) of continuous operators on $\mathcal{H}$, such that $\forall\ \tau \in \mathbb{R}$ and $\forall\ z_\tau \in \mathcal{H}$, the solution can be expressed by $z(t) = U_h(t,\tau)z_\tau$.

• UNIFORMLY ABSORBING SET. Let $\mu \to 0$ exponentially fast. Then there exists a uniformly absorbing set in $\mathcal{H}$ for the family of processes $\{U_h(\tau,t),\ h \in F\}$, where F is any bounded set of the space of *translation bounded* functions in $L^2_{loc}(\mathbb{R}, L^2)$.

• UNIFORM ATTRACTOR. Let $\mu \to 0$ exponentially fast. Then there exists a compact and connected uniform attractor $\mathcal{A}$ for $\{U_h(t,\tau),\ h \in H(f)\}$, where f is a *translation compact* function in $L^2_{loc}(\mathbb{R}, L^2)$, and $H(f)$ denotes the *hull* of f. Moreover $\mathcal{A}$ has the form

$$\mathcal{A} = \Big\{ z(0) : z(t) \text{ is a bdd. trajectory of } U_h(t,\tau) \text{ for some } \ h \in H(f) \Big\}.$$

Finally, if $g \in C^1(\mathbb{R})$ and $f \in C^1(\mathbb{R}, L^2)$ is almost periodic in time, then $\mathcal{A}$ has finite Hausdorff dimension.

On the weak limit of a one dimensional dynamical nonlinear von Kármán model

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We consider a one-dimensional nonlinear coupled system of evolution equations describing the longitudinal and transversal displacement for a beam of lenght L. The model was introduced by J.E. Lagnese and G. Leugering [1] and it is a 1-D version of the von Kármán system of equations describing "large deflections" of plates. In this lecture we describe briefly the main steps of our results: The (weak) limit of the above system coincides with the so called Timoshenko's equation which describes also nonlinear vibrations of beams. Our method is very sensible to the boundary conditions as we show giving explicit examples. All result presented in this lecture are a joint work with Prof. Enrique Zuazua [2]

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Uniform stabilization and exact controllability for hyperbolic systems with discontinuous coefficients

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This paper considers the hyperbolic system with discontinuous coefficients in a bounded, open connected set with smooth boundary and controlled through Robin boundary condition. The results on uniform stabilization of the solutions are established. Exact boundary controllability is obtained through Russell's "Controllabily via Stabilizability" principle.

Let Ω be a bounded domain in R^n with a smooth boundary S which consists of the disjoint closed surfaces S_0 and S_1 (the case $S_1 = \emptyset$ is not excluded).
In the cylinder $\Omega\times]0,T[$ we consider the mixed problem

$$\left|\begin{array}{c}
\frac{\partial^2 \boldsymbol{u}(\boldsymbol{x},t)}{\partial t^2} - \sum\limits_{i=1}^{n} \frac{\partial}{\partial x_i}\left(P(\boldsymbol{x})\frac{\partial \boldsymbol{u}(\boldsymbol{x},t)}{\partial x_i}\right) = 0 \qquad \forall(\boldsymbol{x},t)\in\Omega\times]0,T[\\
\boldsymbol{u}(\boldsymbol{x},0) = f_1(\boldsymbol{x}), \qquad \frac{\partial}{\partial t}\boldsymbol{u}(\boldsymbol{x},0) = f_2(\boldsymbol{x}) \qquad \forall \boldsymbol{x}\in\Omega \\
P\frac{\partial \boldsymbol{u}(\boldsymbol{x},t)}{\partial \nu} + a\boldsymbol{u}(\boldsymbol{x},t) + b\boldsymbol{u}_t(\boldsymbol{x},t) = 0 \qquad \forall(\boldsymbol{x},t)\in\Sigma_0 = S_0\times]0,T[, \\
\boldsymbol{u}(\boldsymbol{x},t) = 0 \qquad \forall(\boldsymbol{x},t)\in\Sigma_1 = S_1\times]0,T[
\end{array}\right.$$

Here $\boldsymbol{u} = (u^1(\boldsymbol{x},t),\ldots,u^m(\boldsymbol{x},t))$, $\boldsymbol{x} = (x_1,\ldots,x_n)$, $P(\boldsymbol{x}) = P^*(\boldsymbol{x})$ are square matrix of order $m, \boldsymbol{\nu} = (\nu_1,\ldots,\nu_n)$ is the unit outward normal to the boundary S, and a, b are positive constants.
Assume that

$$P(\boldsymbol{x})\boldsymbol{\xi}\cdot\boldsymbol{\xi}\geq c_0|\boldsymbol{\xi}|^2, \quad c_0>0$$

where $\boldsymbol{\xi} = (\xi^1, \dots, \xi^m)$ is an arbitrary vector.

Let us assume that $\Omega_0 \subset \Omega$ is a bounded domain with sufficiently smooth boundary Γ. We set $\Omega_1 = \Omega \backslash \overline{\Omega}_0$ and assume that the entries $a_{pq}(\boldsymbol{x})$ of the matrix $P(\boldsymbol{x})$ lose continuity on the surface Γ.

1991 Mathematics Subject Classification. Primary 05C38, 15A15; Secondary 05A15, 15A18.

Key words and phrases. Stabilization Uniform, Control Exact, Hyperbolic Systems.

Research of the second author was supported by CNPq, project 301022/94-1/NV.

Buckling of long rods in the presence of a flat obstacle

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We consider the problem of minimizing the functional

$$\int_0^l \frac{\ddot{x}^2 \ddot{y}^2}{2} + gy \, ds$$

with boundary conditions $x(0) = y(0) = \dot{y}(0) = 0$, $\dot{x}(0) = 1$, $x(l) = \Delta > 0$, $y(l) = h << l$, $\dot{x}(l) = 0$, $\dot{y}(l) = 1$, and constraints $\dot{x}^2 + \dot{y}^2 = 1$ and $y(s) \geq 0$ for $0 \leq s \leq l$. This is a mathematical model for the static configuration of a rod of length l, with fixed end points at $x = y = 0$ and $x = \Delta < l$, $y = h << l$, which is above a flat floor $y \geq 0$, in the presence of gravity (that points for the negative y-direction).

High Weissenberg number asymptotics for viscoelastic flows

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Viscoelastic flows at high deformation rates involve singular features, such as stress boundary layers and reentrant corner singularities, which pose a major challenge to numerical simulation. The lecture reviews some recent work towards developing an asymptotic approach to these problems. Clearly, the flow behavior at large Weissenberg numbers depends strongly on the constitutive model; the lecture focusses primarily on the upper convected Maxwell fluid. In particular, the following issues are discussed.

1. The formal limit of infinite Weissenberg number, in the same sense as the Euler equations are the limit of the Navier-Stokes equations for the limit of infinite Reynolds numbers. It turns out that there is a transformation of variables which leads from the infinite Weissenberg number limit of the upper convected Maxwell fluid to Euler equations.

2. Scalings for stress boundary layers and the resulting boundary layer equations.

3. Matched asymptotic solutions for reentrant corners.

Generalized solutions to the equations of compressible Bingham fluid

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Equations

$$\rho(u_t + uu_x) = -p(\rho)_x + \sigma(u_x)_x + \rho G(t,x),$$

$$\rho_t + (\rho u)_x = 0, \quad \sigma(s) = \nu s + \sigma_0 \text{sign} s,$$

are considered to describe one-dimensional flows of the Bingham compressible fluid in a bounded domain $\Omega = \{x : 0 < x < l\}$. A notion of the generalized solution is introduced to study a joint moution of rigid and fluid zones without incorporating of free boundaries corresponding to the fluid-rigid interfaces. Here, a part of the media with zero rate of deformation, $r(t) = \{x : u_x(t,x) = 0\}$, is called a rigid zone, and the part $f(t) = \{x : u_x(t,x) \neq 0\}$ is called a fluid zone. A global unique solvability is proved and examples are given to illustrate the notion of the generalized solution. It is shown that, given a rigid initial state with meas$r(0) = |\Omega|$, a fluid zone appears immediatly, i.e. meas$f(t) > 0$ for $t > 0$, provided the yield stress parameter σ_0 is great enough. On the other hand, if the initial state is pure liquid, meas$f(0) = |\Omega|$, then a rigid zone also appears immediatly.

Existence and boundary stabilization of a nonlinear hyperbolic equation with time-dependent coefficients

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Let Ω be a bounded domain of $\mathbf{R}^n$ with C^2 boundary Γ. Let x^0 be a point of $\mathbf{R}^n$ and $m(x) = x - x^0$, with $x \in \mathbf{R}^n$, such that:

$$\Gamma_0 = \{x \in \Gamma; m(x) \cdot \nu(x) \geq 0\} \text{ and } \Gamma_1 = \{x \in \Gamma; m(x) \cdot \nu(x) < 0\},$$

where $\nu(x)$ is the exterior unit normal at x. Let us consider the nonhomogeneous boundary value problem:

$$(*) \quad \begin{cases} K(x,t)u_{tt} + A(t)u + F(x,t,u,\nabla u) = 0 & \text{in} \quad \Omega \times]0,\infty[, \\ u = 0 & \text{on} \quad \Gamma_1 \times]0,\infty[, \\ \dfrac{\partial u}{\partial \nu_A} + m(x) \cdot \nu(x) u_t = 0 & \text{on} \quad \Gamma_0 \times]0,\infty[, \\ u(0) = u^0 \text{ and } u_t(0) = u^1 & \text{in} \quad \Omega, \end{cases}$$

where

$$A(t) = -\sum_{j=1}^{n} \frac{\partial}{\partial x_j}\left(a(x,t)\frac{\partial u}{\partial x_j}\right).$$

With restrictions on $K(x,t)$, $a(x,t)$ and F, we prove the existence, uniqueness and exponential decay of solutions of the problem $(*)$.

Asymptotic behaviour of solution to a system of nonlinear PDE arrising from the study of phase transitions in shape memory alloys

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In the talk two recent works jointly by J. Sprekels, S. Zheng & P. Zhu and by J. Sprekels & S. Zheng, respectively are presented. A system of nonlinear partial differential equations governing the dynamics of martensitic phase transitions in shape memory alloys under the presence of a viscous stress is investigated. The corresponding free energy is assumed in Landau-Ginzburg form and nonconvex as a function of the order parameter. The results on asymptotic behaviour of solution as time goes to infinity as well as existence of a maximal compact attractor have been obtained.

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