Universität Konstanz

Partial Differential Equations
– Thermo & Visco & Elasticity –

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Workshop on

Partial Differential Equations
– Thermo & Visco & Elasticity –

July 31 – August 4, 2000

University of Konstanz, Germany

Program Abstracts Participants

Jaime E. Muñoz Rivera and Reinhard Racke

122/2000
Universität Konstanz
Fachbereich Mathematik und Statistik

Preface

From July 31 until August 4, 2000, the "Workshop on Partial Differential Equations — Thermo & Visco & Elasticity" will take place at the University of Konstanz. By now, circa 60 participants are expected from Brazil, China, France, Germany, Greece, Italy, Japan, Poland, Saudi Arabia and the USA.

The announced talks cover a wide range of topics within the field of Thermo & Visco & Elasticity, the abstracts of the speakers are collected here, together with the planned schedule of the talks and information on the affiliations of the participants.

The workshop can be realized through the support by the DFG (mainly), but also by CNPq-DLR (on the Brazil-German agreement on scientific-technological cooperation) and by the Universitätsgesellschaft e.V. Konstanz. The organizers are grateful to these organizations for their support; moreover they thank the people from the administration of the University of Konstanz for kindly supporting the local organization.

Jaime E. Muñoz Rivera   Petrópolis
Reinhard Racke   Konstanz

June 30, 2000

Program

Workshop on Partial Differential Equations
— Thermo & Visco & Elasticity —
University of Konstanz, July 31 – August 4, 2000

Monday, July 31

08:45.- *Registration starting*

09:15.- *Opening*

09:40–10:25 **G. Perla Menzala (Petrópolis, Rio de Janeiro)**
Uniform stabilization of the full von Kármán system of dynamic viscoelasticity with memory

10:30.- *Coffee break*

11:00–11:45 **H. Koch (Heidelberg)**
Self-sustained oscillations of visco-elastic materials

11:55–12:25 **M. Nakao (Fukuoka)**
Decay and global existence for the quasilinear wave equations in exterior domains

12:30.- *Lunch*

14:30–15:15 **M. Renardy (Blacksburgh)**
Backward uniqueness in linear thermoelasticity

15:25–15:55 **M. Reissig (Freiberg)**
About some new results for the model of three-dimensional thermoelasticity

16:00.- *Coffee break*

16:20–16:50 **C. Eck (Erlangen)**
On the solvability of thermo-viscoelastic contact problems with Coulomb friction

17:00–17:30 **T.F. Ma (Maringá)**
Some equations modeling beams on elastic bearings

Workshop on Partial Differential Equations
— Thermo & Visco & Elasticity —
University of Konstanz, July 31 – August 4, 2000

Tuesday, August 1

09:00–09:45 **I. Lasiecka (Charlottesville)**
Uniform stability in nonlinear dynamic elasticity with thermoelasticity

09:55–10:25 **H.-D. Alber (Darmstadt)**
Evolving microstructure and homogenization

10:30.- *Coffee break*

11:00–11:45 **S. Zheng (Shanghai)**
Maximal attractors for the system of one-dimensional polytropic viscous ideal gas

11:55–12:25 **D. Andrade (Maringá)**
A nonlinear wave equation with viscoelastic boundary condition

12:30.- *Lunch*

14:30–15:15 **A. Benabdallah (Besançon)**
Exponential decay rates for a full von Kármán thermoelastic system with nonlinear thermal coupling

15:25–15:55 **S.J. Watson (Baton Rouge)**
Unique global solvability and temporal asymptotics in one-dimensional thermoviscoelasticity

16:00.- *Coffee break*

16:20–16:50 **K. Chełminski (Darmstadt)**
Initial-boundary value problems for constitutive equations with internal variables

17:00–17:30 **W. Domański (Warsaw)**
Weakly nonlinear elastic and magnetoelastic waves

17:40–18:10 **E. Lueders (Londrina)**
Convergence of solutions of a third order nonlinear Schrödinger equation

Wednesday, August 2

09:00–09:45 **Y. Shibata (Tokyo)**
L_p approach to the Ginzburg-Landau equations

09:55–10:25 **Y.-G. Wang (Shanghai)**
Microlocal analysis in semilinear thermoelasticity

10:30.- *Coffee break*

11:00–12:00 **C.M. Dafermos (Providence)**
Challenging problems in analysis from the theory of materials with fading memory

12:10–12:40 **O. Lopes (Campinas)**
Nonlocal variational problems arising in long wave propagation

12:45.- *Lunch*

Thursday, August 3

09:00–09:45 **S.A. Antman (College Park)**
Incompressible nonlinearly viscoelastic rods

09:55–10:25 **S. Kawashima (Fukuoka)**
Existence and stability of stationary waves for the compressible Navier-Stokes equation in the half space

10:30.- *Coffee break*

11:00–11:45 **S. Jiang (Beijing)**
On spherically symmetric solutions of the compressible isentropic Navier-Stokes equations

11:55–12:25 **H. Frid Neto (Rio de Janeiro)**
On periodic solutions of conservation laws

12:30.- *Lunch*

14:30–15:15 **J.U. Kim (Blacksburgh)**
On a stochastic hyperbolic system in linear elasticity

15:25–15:55 **S. Shimizu (Hamamatsu)**
On the Schauder estimate of solutions to elastostatic interface problems

16:00.- *Coffee break*

16:20–16:50 **B. Ducomet (Bruyères-le-Châtel)**
Asymptotic behaviour for a model of non monotone fluid in one dimension: the thermal case.

17:00–17:30 **J. Gwinner (München)**
Discretization of dynamic contact problems in one-dimensional linear thermoelasticity

18:30–19:30 **Poster Session**

Friday, August 4

09:00–09:45 **M. Slemrod (Madison)**
Chapman Enskog expansion

09:55–10:25 **L. Fatori (Londrina)**
Energy decay for hyperbolic thermoelastic systems of memory type

10:30.- *Coffee break*

11:00–11:30 **S.A. Messaoudi (Dhahran)**
Blow up in a nonlinearly damped wave equation

11:40–12:10 **F. Ammar Khodja (Besançon)**
Simultaneous boundary stabilization of a system of wave equations

12:15.- *Lunch*

14:00–14:45 **G. Dassios (Patras)**
The far-field behaviour of the scattered thermoelastic wave

14:55–15:25 **Z. Liu (Duluth)**
Exponential energy decay of an elastic beam with local viscoelasticity

15:30.- *Coffee break*

15:50–16:20 **V. Georgiev (L'Aquila)**
Global solution for viscoelastic problem with memory term

16:30 .- *The End*

Abstracts

Evolving microstructure and homogenization

HANS-DIETER ALBER
Technische Universität Darmstadt

In the talk, a mathematical model for the temporally evolving microstructure generated by phase changes in a single crystal alloy is presented and the homogenization of the partial differential equations in this model is discussed. The results I present are partially formal, since I can not prove convergence of solutions of the equations of the microstructure model to solutions of the homogenized equations.

To model the microstructure, the sharp interface approach is used. The free energy does not have a surface part. Instead, the driving traction for the interface is generated by a jump of the Eshelby tensor at the phase interfaces. This jump is caused by the misfit strain originating from the different values of the parameters of the crystal lattice in the different phases. The mathematical model contains evolution equations for internal variables, since the different phases are assumed to be inelastic. Moreover, it contains a distributional partial differential equation for the order parameter characterizing the different phases. To study the homogenization of this distributional equation, a family of solutions of the model equations depending on the fast variable is needed and defined.

Also the special situation of temporally fixed microstructure is discussed.

Simultaneous boundary stabilization of a system of wave equations

F. AMMAR KHODJA
Université de Franche Comté, Besançon

The problem we deal with is:

$$\begin{cases} u_{tt} = u_{xx} + b(x)v_t & \text{in } (0,\infty)\times(0,1) \\ v_{tt} = \eta^2 v_{xx} - b(x)u_t & \text{in } (0,\infty)\times(0,1) \\ u(t,0) = v(t,0) = 0, u(t,1) = f(t), \quad \eta^2 v_x(t,1) = g(t) & t\in(0,\infty) \\ u(0,x) = u_0(x),\ u_t(0,x) = u_1(x),\ v(0,x) = v_0(x),\ v_t(0,x) = v_1(x) \end{cases}$$

We would like to stabilize *simultaneously* this system by two boundary control forces which are related by the relation $f' = g$ on $(0,\infty)$. A natural choice of the force g which makes our system dissipative is:

$$g(t) = -\alpha\left(u_x(t,1) + v_t(t,1)\right), \quad \alpha > 0$$

We then get the system:

$$\begin{cases} u_{tt} = u_{xx} + b(x)v_t & \text{in } (0,\infty)\times(0,1) \\ v_{tt} = \eta^2 v_{xx} - b(x)u_t & \text{in } (0,\infty)\times(0,1 \\ u(t,0) = v(t,0) = 0, \\ \eta^2 v_x(t,1) = u_t(t,1) = -\alpha\left(u_x(t,1) + v_t(t,1)\right) & t\in(0,\infty) \\ u(0,x) = u_0(x),\ u_t(0,x) = u_1(x),\ v(0,x) = v_0(x),\ v_t(0,x) = v_1(x) \end{cases} \tag{1}$$

Our result for system (1) is:

Theorem: *Assume that* $b \in C([0,1])$ *and* $\alpha > 0$. *Then:*

(i) If $\eta \neq 1$, (1) is exponentially stable if and only it is strongly stable and

$$\eta = \frac{2p+1}{q}, \quad \textit{for some } (p,q) \in \mathbb{Z} \times \mathbb{Z}^*$$

(ii) If $\eta = 1$, (1) is exponentially stable if and only it is strongly stable and

$$\overline{b} := \int_0^1 b(x)dx \neq (2k+1)\frac{\pi}{2} \quad \textit{for any} \;\; k \in \mathbb{Z}.$$

A nonlinear wave equation with viscoelastic boundary condition

DOHERTY ANDRADE (UEM)
JAIME E. MUÑOZ RIVERA (LNCC)

In this work, we study the global existence and exponential decay of solutions of the nonlinear one-dimensional wave equation with a viscoelastic boundary condition.

$$u_{tt}(x,t) - [\sigma(u_x(x,t))]_x = f(x,t), \;\; 0 < x < 1, \;\; t > 0, \tag{1}$$

$$u(0,t) = 0, \;\; u(1,t) + \int_0^t a(t-\tau)\sigma(u_x(1,\tau))d\tau = g(t), \;\; \text{for } t > 0 \tag{2}$$

$$u(x,0) = u_0(x), \;\; u_t(x,0) = u_1(x), \;\;\; \text{for } 0 < x < 1. \tag{3}$$

The integral equation (2) is a nonlinear and nonlocal boundary condition which include the memory effect. Additionally to conditions (2)–(3) we consider the history condition

$$u(0,t) = 0, t \leq 0,$$

which means that the viscoelastic element is undeformed before $t = 0$. Here by u we are denoting the displacement, by σ the stress, by a the relaxation function and finally by f and g we denote external sources.

Our main result prove the existence of global smooth solution for small initial data. This result is an improvement of Qin's result [3], in the sense that we only require that the initial data (u_0, u_1) is small in the $H^2 \times H^1$-norm, this means that the L^2-norm of $u_{0,xxx}$ and $u_{1,xx}$ can be taken large. Somehow, this result is optimal in the sense that if we take initial data large in the $H^2 \times H^1$-norm, then the solution will blow up in a finite time as was proved in Qin [4]. Moreover we prove that the solution decays exponentially provided the resolvent kernel of the relaxation function, k decays exponentially. While when k decays polynomially, the solution decays polynomially and with the same rate. That is, the rate of decay of the solution is given by the rate of decay of the relaxation function.

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Incompressible nonlinearly viscoelastic rods

Stuart S. Antman
University of Maryland, College Park

Those equations of solid mechanics having but a single independent spatial variable describe very special motions of three-dimensional bodies, special motions of shells (such as cylindrical or axisymmetric motions), and general motion of rods. The last class is the richest. Initial-boundary-value problems for (a hierarchy of theories of) nonlinearly viscoelastic rods of strain-rate type have a fairly complete theory, the chief source of difficulty being the rod-theoretic requirement that the deformations preserve orientation, i.e., that a rod-theoretic Jacobian be positive everywhere. The entire mathematical structure of the governing equations changes when this Jacobian is constrained to be 1, i.e., when the rod models an incompressible body. This lecture describes the analysis of the partial differential equations for incompressible viscoelastic rods, emphasizing its novel aspects.

Exponential decay rates for a full von Kármán thermoelastic system with nonlinear thermal coupling

Assia Benabdallah
Université de Franche Comté, Besançon

The full von Kármán system accounting for in plane acceleration and nonlinear thermal effects is considered. The results obtained in this paper: (i) wellposedness of regular and weak (finite energy) solutions, (ii) uniform decay rates of energy function, extend those obtained earlier by the same authors for a more restrictive model which does not account for the nonlinear thermal coupling.
Key words: full von Kármán system, thermoelasticity, uniform decay rates, analytic semi-groups.

Initial-boundary value problems for constitutive equations with internal variables

KRZYSZTOF CHEŁMIŃSKI *
Technische Universität Darmstadt

In this lecture, we will study the following problem: let $\Omega \subset \mathbb{R}^3$ be a bounded domain with smooth boundary $\partial\Omega$. Find the velocity field $v : \Omega \times \mathbb{R}_+ \to \mathbb{R}^3$, the strain tensor $\varepsilon : \Omega \times \mathbb{R}_+ \to \mathcal{S}^3$ (here $\mathcal{S}^3$ denotes the set of 3×3 real, symmetric matrices) and the vector of internal variables $z : \Omega \times \mathbb{R}_+ \to \mathbb{R}^N$, which satisfy the system of equations from the theory of inelastic deformations with the inelastic constitutive equation of monotone type

$$\begin{aligned}
\rho v_t(x,t) &= \operatorname{div}_x \mathcal{D}\Big(\varepsilon(x,t) - Bz(x,t)\Big) + F(x,t)\,, \\
\varepsilon_t(x,t) &= \frac{1}{2}\Big(\nabla_x v(x,t) + \nabla_x^T v(x,t)\Big)\,, \\
z_t(x,t) &\in g\Big(- \rho \nabla_z \psi(\varepsilon(x,t), z(x,t))\Big)\,.
\end{aligned}$$

The `first equation` results from the balance of momentum. The operator $\mathcal{D} : \mathcal{S}^3 \to \mathcal{S}^3$ is the elasticity tensor, and we assume that $\mathcal{D}$ is symmetric and positive definite. In the theory of inelastic material behaviour of metals with internal variables, the vector z consists of the plastic strain tensor $\varepsilon^p \in \mathcal{S}^3$ and of another components $\tilde{z}$ (for example the isotropic hardening, the kinematic hardening, the damage variables ...) whose length depends on the considered model. The linear operator $B : \mathbb{R}^N \to \mathcal{S}^3$ is the projection on the direction of plastic strains. The function $F : \Omega \times \mathbb{R}_+ \to \mathbb{R}^3$ describes the external body forces. The `second equation` is a consequence of the definition of the strain tensor. The `third equation`, given in the form of a differential inclusion, is called the inelastic constitutive relation. For models of monotone type, we require that the multifunction $g : D(g) \subset \mathbb{R}^N \to \mathcal{P}(\mathbb{R}^N)$ is monotone and additionally satisfies $0 \in D(g)$, and $0 \in g(0)$. Here, the free energy function ψ associated with the model is defined by

$$\rho\psi(\varepsilon, z) = \frac{1}{2}\mathcal{D}(\varepsilon - Bz)\cdot(\varepsilon - Bz) + \frac{1}{2}Lz \cdot z$$

with a positive semi-definite, symmetric, $N \times N$ matrix L additionally satisfying the condition $B^T\mathcal{D}B + L > 0$. We consider our system of equations with the Dirichlet boundary condition

$$v(x,t) = g_D(x,t) \quad \text{for } x \in \partial\Omega\,,\ t \geq 0$$

or with the Neumann boundary condition

$$\mathcal{D}\Big(\varepsilon(x,t) - Bz(x,t)\Big)\cdot n(x) = g_N(x,t) \quad \text{for } x \in \partial\Omega,\ t \geq 0,$$

where $n(x)$ denotes the outer normal vector to the boundary $\partial\Omega$ at the point $x \in \partial\Omega$. The functions $g_D, g_N : \Omega \times \mathbb{R}_+ \to \mathbb{R}^3$ are given boundary data. Moreover the initial conditions are in the form

$$v(x,0) = v^0(x)\,, \quad \varepsilon(x,0) = \varepsilon^0(x)\,, \quad z(x,0) = z^0(x)$$

with given functions $v^0 : \Omega \to \mathbb{R}^3$, $\varepsilon^0 : \Omega \to \mathcal{S}^3$, $z^0 : \Omega \to \mathbb{R}^N$.

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Challenging problems in analysis from the theory of materials with fading memory

Constantine M. Dafermos
Brown University, Providence

The lecture will first review the (thermo)mechanical theory of materials with "fading memory", which was developed in the 1960's with the aim of incorporating the classical theories of viscoelasticity and non-newtonian fluids into the framework of rational mechanics. Then, it will describe the difficult analytical problems induced by the competition between hyperbolicity and dissipation in the governing functional-partial differential equations, and it will survey briefly past successes and future challenges.

The far-field behaviour of the scattered thermoelastic wave

George Dassios
University of Patras and ICEHT-FORTH

A plane thermoelastic field, consisted of two P-type and one S-type displacement as well as two thermal waves, is falling on a bounded smooth 3-D obstacle. As a consequence of this scattering process, similar five types of waves are generated in the medium exterior to the scatter. The boundary conditions on the surface of the obstacle could be anyone of the standard boundary conditions of thermoelastic theory. Special radiation conditions at infinity establish, among other things, that the scattered waves exhibit an asymptotic attenuation of the type of inverse distance. We show that these radiation conditions provide the leading terms of the series expansions of the scattered fields in inverse powers of distance. All five series involved, one for each one of the five scattered waves, converge absolutely and uniformly outside the smallest sphere that circumscribes the scatterer. A recurence scheme is proposed which recovers all the coefficients of all five expansions from the leading coefficient of the corresponding series. An amazing conclusion has to do with the fact that the leading terms, and therefore the full expansios of the two thermal series, are related to the corresponding leading terms of the elastic series that express the P-type of waves. In scalar form, the expansion of the scattered thermoelastic wave involves eleven series and if specific four leading terms are given, then all eleven series are completely obtained.

Weakly nonlinear elastic and magnetoelastic waves

Włodzimierz Domański
Polish Academy of Sciences, Warsaw

Propagation and interaction of weakly nonlinear elastic and magnetoelastic waves are studied. Asymptotic method of weakly nonlinear geometric optics is applied to derive simplified asymptotic equations for the wave amplitudes. Particular attention is paid to the cases in which a local loss of convexity and strict hyperbolicity is observed. The resonant interactions are also studied.

Asymptotic behaviour for a model of non monotone fluid in one dimension: the thermal case

B. Ducomet
CEA-Département de Physique Théorique et Appliquée, Bruyères-le-Châtel

We consider a one-dimensional model of quantum fluid, described by a system of compressible Navier-Stokes type, with a non monotone equation of state. By using methods of non linear thermoelasticity, we prove some attractor properties of globally defined (large) solutions of the free boundary problem for our model, for large time, provided viscous and thermal regularizations are sufficient.

On the solvability of thermo–viscoelastic contact problems with Coulomb friction

Christof Eck
Universität Erlangen–Nürnberg

In models for contact problems with friction, it is often necessary to include the aspect of heat transport, because friction generates heat. A suitable model consists of a viscoelastic contact problem and a heat equation; both problems are coupled by volume terms and by boundary terms modeling the generation of heat by friction. The weak formulation of the problem is given by a variational inequality for the contact problem and a variational equation for the heat transport.

The solution of the problem by variational methods raises several difficulties. One problem is the non–monotonicity and non–compactness of the friction functional; this difficulty is tackled by the proof of a regularity result for the contact problem. If the constitutive laws for the material are linear, then the heat generated by friction, the viscous heat and also the deformation heat are of a higher order of growth than the corresponding elliptic bilinear forms. This fact complicates the derivation of the required a priori estimates essentially.

In the present contribution, we establish solvability results for three different cases: a linearized model, a nonlinear model with nonlinear heat conductivity having a sufficiently strong growth, and a model with linear constitutive laws including a heat radiation boundary condition. In all models, the contact condition of Signorini type is formulated with the displacement velocities.

Energy decay for hyperbolic thermoelastic systems of memory type

Luci Fatori
Universidade de Londrina

In this work, we study the hyperbolic thermoelastic system, which is obtained when instead of the Fourier's law for the heat flux relation, we follow the linearized model proposed by Gurtin and Pipkin about the memory theory of heat conduction. In this case the thermoelastic model

is fully hyperbolic. We show that the linear system is well posed and that the solution decays exponentially to zero as time goes to infinity.

On periodic solutions of conservation laws

HERMANO FRID NETO †
Instituto de Matemática Pura e Aplicada – IMPA, Rio de Janeiro

In this talk, we present some recent results on the decay of periodic solutions for systems of conservation laws of several different types including some of the most frequently appearing in applications, such as models for gas dynamics and elasticity. We also discuss some open problems in this context.

Global solution for viscoelasticity problem with memory term

VLADIMIR GEORGIEV
Università dell'Aquila, Coppito (L'Aquila)

We study the following Cauchy problem for equations arising from the theory of viscoelasticity

$$m_{tt} - \nabla \cdot \sigma(\nabla m) - \Gamma' * \nabla \cdot \sigma(\nabla m) = f(\nabla m), \quad (1)$$
$$m(x,0) = m_0(x), \quad (2)$$
$$m_t(x,0) = m_1(x), \quad (3)$$

where $m : \mathbb{R}^n_x \times \mathbb{R}^+_t \longrightarrow \mathbb{R}^n$, $*$ denotes the convolution in time, i.e., $a * b = \int_0^t a(t-\tau)b(\tau)\, d\tau, \quad t > 0$, Γ' is the memory kernel which describes how history of the strain affects the present stress. Under suitable assumptions on the nonlinear functions f, σ and the kernel of the memory term, we establish existence of global small data solutions as well as the decay rate in time of the solution.

Discretization of dynamic contact problems in one-dimensional linear thermoelasticity

J. GWINNER
Universität der Bundeswehr München, Neubiberg

In this contribution, we study the class of time-dependent contact problems in one-dimensional linear thermoelasticity as analysed in [2] and [3]. Our aim is to establish norm convergence for full space time discretization. The discretization scheme combines a backward Euler scheme for

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*Key words and phrases.*Conservation laws, Riemann problems, periodic solutions.

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time discretization and piecewise linear spline approximation for space discretization. We put emphasis on the treatment of inhomogeneous boundary terms which lead to a nonconforming approximation scheme. For this purpose, we can partly simplify, partly have to extend the discretization theory recently developed in [1].

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On spherically symmetric solutions of the compressible isentropic Navier-Stokes equations

Song Jiang
Ping Zhang
Institute of Applied Physics and Computational Mathematics, Beijing

We prove the global existence of weak solutions to the Cauchy problem for the compressible isentropic Navier-Stokes equations in $\mathbb{R}^n$ $(n = 2, 3)$ when the Cauchy data are spherically symmetric. The proof is based on the exploitation of the one-dimensional feature of symmetric solutions and make use of a new property induced by the viscous flux. The present paper extends Lions' existence theorem [1] to the case $1 < \gamma < \gamma_n$ for spherically symmetric pressure, $\gamma_n = 3/2$ for $n = 2$ and $\gamma_n = 9/5$ for $n = 3$.

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Existence and stability of stationary waves for the compressible Navier-Stokes equation in the half space

Shuichi Kawashima
Kyushu University, Fukuoka

We discuss large-time behavior of solutions to the initial-boundary value problem for the compressible Navier-Stokes equation in the one-dimensional half space. The problem is formulated as

$$\begin{gathered}\rho_t + (\rho u)_x = 0\,,\\ (\rho u)_t + (\rho u^2 + p)_x = (\mu u_x)_x\,, \quad x > 0\,, \quad t > 0\,,\\ u(0,t) = u_b\,, \quad t > 0\,,\\ (\rho, u)(x,0) = (\rho_0, u_0)(x)\,, \quad x > 0\,.\end{gathered}$$

Here, the unknown functions ρ and u represent the mass density and the velocity of the gas, respectively, p is the pressure which is given in terms of $\rho > 0$ as $p = K\rho^\gamma$, where $K > 0$ and $\gamma > 1$ are constants, and μ is the viscosity coefficient which is assumed to be a positive constant.

We are interested in the outflow problem. This is the case where the boundary data u_b is a negative constant, i.e., $u_b < 0$. We consider this problem under the following space-asymptotic condition:

$$(\rho_0, u_0)(x) \to (\rho_+, u_+) \quad \text{as} \quad x \to \infty\,,$$

where $\rho_+ > 0$ and $u_+ \neq u_b$ are given constants. We wish to give a detailed description of the large-time behavior of the solution $(\rho, u)(x,t)$ to the problem. It is expected that for $t \to \infty$, the solution $(\rho, u)(x,t)$ is asymptotically described by a viscous shock wave, a stationary wave, a rarefaction wave, or their superposition. Of course, such a nonlinear wave giving the large-time description of the solution should be determined from the space-asymptotic state (ρ_+, u_+) and the boundary data $u_b < 0$.

In this talk, we mainly discuss the case where the stationary wave is dominant for $t \to \infty$. In paticular, we classify the situation and prove the existence of a stationary wave in a certain situation. Furthermore, we show the asymptotic stability of this stationary wave for $t \to \infty$ under the smallness condition on the initial perturbation.

On a stochastic hyperbolic system in linear elasticity

Jong Uhn Kim
Virginia Tech, Blacksburg

In this talk, we discuss the Cauchy problem for linear elasticity with a space-time white noise forcing term. We show that the solution can be represented by a formula analogous to the Riesz formula for solutions of wave equations. The solution is a generalized stochastic process and is obtained as the limit of a sequence of ordinary stochastic processes. Our basic tool is the Hilbert space method combined with geometric properties inherent with a hyperbolic system.

Self-sustained oscillations of visco-elastic materials

HERBERT KOCH
STUART S. ANTMAN
Universität Heidelberg

The talk consists of two parts. First, we study well-posedness for a class of initial boundary value problems describing visco-elastic materials. Then, we derive a Hopf-bifurcation theorem. This is nontrivial, because the semiflow is noncompact and its domain of definition is a Banach manifold.

In the second part, we verify the assumptions for a model for slip-stick motion. For that special situation, we obtain very precise and surprising information about the bifurcation points.

Uniform stability in nonlinear dynamic elasticity with thermoelasticity

IRENA LASIECKA
University of Virginia, Charlottesville

The full von Kármán system accounting for in plane accelerations and thermal effects is considered. Wellposedness of regular and finite energy (weak) solutions, corresponding to this system, is established in [1].

Since the original (uncontrolled) model is only *strongly* stable, but not *uniformly* stable, the main question of interest becomes: what is the 'minimal amount' of dissipation necessary to obtain uniform decay rates for the energy of the overall system?

Our main result states that boundary *nonlinear* dissipation affecting only the velocity field, representing in plane displacements of the plate and placed only on a suitable *portion* of the part of the boundary , suffices for the uniform decay rates of the energy corresponding to the entire system. These decay rates are described by a suitable nonlinear differential equation, whose coefficients depend on the growth of the nonlinear function at the origin.

The key role in this result is played by: (i) new sharp regularity estimates for the boundary traces of elastic systems and (ii) newly established properties of analyticity of nonlinear semigroups arising in thermoelastic system with free boundary conditions.

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Exponential energy decay of an elastic beam with local viscoelasticity

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In this paper, we study the energy decay rate for an Euler-Bernoulli beam with a segment made of elastic material and the other segment of viscoelastic material, Kelvin-Voigt or Boltzmann type.

Let $u(x,t)$ denote the longitudinal displacements of the beam; dot, prime and the subscript s represent the derivative with respect to t, x, and s, respectively. Let $b(x)$ be a function with local support on $[0, L]$.

The linear viscoelastic material of Boltzmann type assumes that the instantaneous stress depends on the instantaneous strain and the entire history of strain rate linearly. The system is governed by the following equations:

$$\begin{cases} \ddot{u}(x,t) - \left[a(x)u'(x,t) - b(x)\displaystyle\int_0^\infty g_s(s)(u'(x,t) - u'(x,t-s))ds\right]' = 0, \\ u(0,t) = u(L,t) = 0, \\ u(x,s) = u^0(x,s), \quad u_t(x,s) = u^1(x,s) \ \text{ for } \ s \le 0. \end{cases}$$

The linear viscoelastic material of Kelvin-Voigt type assumes that the instantaneous stress depends on the instantaneous strain and strain rate linearly. The system is governed by the following equations:

$$\begin{cases} m(x)\ddot{u}(x,t) - \left[a(x)u'(x,t) + b(x)\dot{u}'(x,t)\right]' = 0, \\ u(0,t) = u(L,t) = 0, \\ u(x,0) = u^0(x), \quad u_t(x,0) = u^1(x). \end{cases}$$

In the case of Kelvin-Voigt material, we show that the energy corresponding to the longitudinal motion decays exponentially when the material properties changes smoothly at the interface. This is in contrast to our previous results in [1] where we proved the non-exponential decay when the material properties are discontinuous at the interface. In the case of Boltzmann type of material, we show that the energy corresponding to longitudinal motion decays exponentially for a class of relaxation function.

Then we extend the above results to the case of transverse motion of the beam.

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Towards a stability theory of double solitons for integrable systems

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The stability of double solitons for KdV equation has been proved in 1992 by J.Maddocks and R.Sachs but part of the proof depends on the fact that the Euler-Lagrange equations for the conserved quantities are ODE's.
Since there are many other integrable systems that have double solitons solutions and whose conserved quantities are not local integrals in one space variable (for instance: BO,ILW,DS and KP), it is desirable to have a more general stability theory that covers those cases.
In our talk we indicate a possible direction to achieve such a theory.

Convergence of solutions of a third order nonlinear Schrödinger equation

Edson Lueders
Universidade Estadual de Londrina

Consider the initial value problem for the third order nonlinear Schrödinger equation

$$iu_t + iau_{xxx} + bu_{xx} = \alpha\,|u|^2\,u + i\beta\,|u|^2_x\,u + i\gamma\,|u|^2\,u_x,$$

where $u = u(x,t)$ is complex-valued and $a, b, \alpha, \beta, \gamma$ are real constants with $a\beta \neq 0$. It is well known that the Cauchy problem is globally well-posed on suitable Sobolev spaces if $a \neq 0$. We study the convergence as $a \to 0$ of the family of solutions u_a of the above equation to the solution of the derivative nonlinear Schrödinger equation

$$iu_t + bu_{xx} = \alpha\,|u|^{\,2}u + i\beta\,|u|^2_x\,u + i\gamma\,|u|^2\,u_x.$$

Some equations modeling beams on elastic bearings

To Fu Ma
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We use variational methods to study a class of fourth order problems with nonlinear boundary conditions which is motivated by the theory of vibrating and bending elastic beams on elastic supports.

Our results are concerned with the existence of solutions in the presence of symmetries, singularities or monotonicity.

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Blow up in a nonlinearly damped wave equation

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In this paper, we consider the nonlinearly damped semilinear wave equation
$u_{tt} - \Delta = u + au_t|u_t|^{m-2} = 3Dbu|u|^{p-2}$
associated with initial and Dirichlet boundary conditions. We prove that any strong solution, with negative initial energy, blows up in finite time, if $p > m$. This result improves an earlier one of Georgiev and Todoro va and helps in understanding the abstract results of Levine and Serrin.

Key words : nonlinear damping, negative initial energy, noncontinuation, blow up, finite time.
AMS Classification : 35 L 45

Decay and global existence for the quasilinear wave equations in exterior domains

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In this talk, we consider the initial-boundary value problem for the quasilinear wave equations

$$u_{tt} - \text{div}\{\sigma(|\nabla u|^2)\nabla u\} + a(x)u_t = 0 \text{ in } \Omega \times [0, \infty),$$

$$u(x,0) = u_0(x), u_t(x,0) = u_1(x) \text{ and } u|_{\partial\Omega} = 0,$$

where Ω is an exterior domain in $\mathbb{R}^N$ to a finite body V with a compact smooth boundary $\partial\Omega$, $\sigma(|\nabla u|^2)$ is a nonlinear term like $\sigma(|\nabla u|^2) = 1/\sqrt{1 + |\nabla u|^2}$and $a(x)$ is a nonnegative function specified below.

Following J.L.Lions (1988) we introduce for $x_0 \in \mathbb{R}^N$,

$$\Gamma(x_0) = \{x \in \partial\Omega | (x - x_0) \cdot \nu(x) > 0\},$$

where $\nu(x)$ is the outward normal at x. Note that $\Gamma(x_0) = \phi$ means that V is star-shaped with respect to x_0. Then, we make the following:

Hyp.A. There exists an x_0 and an open set ω in $\bar{\Omega}$ such that

$$\omega \subset \Gamma(\bar{x}_0) \quad \text{and} \quad a(x) \geq \varepsilon_0 > 0$$

for some ε_0.

Hyp.B. There exists $L > 0$ such that $a(x) \geq \varepsilon > 0$ if, $|x| \geq L$.

Under **Hyp.A** and **Hyp.B**, we can derive a total energy decay and L^2 boundedness of the solutions for the linear wave equation with the dissipation $a(x)u_t$ (M.Nakao, preprint(1999)). The first object of this talk is to apply these estimates to the quasilinear equation and show a global existence of smooth small amplitude solutions.

Under Hyp.A with the condition that suppl.$a(\cdot)$ is compact, we can derive a local energy decay for the linear wave equation in exterior domains with the dissipation (M.Nakao (1998)). By combining this with the $L^p - L^q$ estimates for the Cauchy problem in the whole space, we can prove L^p estimates for the linear equation in exterior domains. The second object is to apply this to the global existence problem for the quasilinear wave equation with such a localized dissipation. We note that no geometrical condition on $\partial\Omega$ is imposed in our arguments.

Uniform stabilization of the full von Kármán system of dynamic viscoelasticity with memory

GUSTAVO PERLA MENZALA
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In this lecture, we will consider the dynamical full von Kármán system of equations for viscoelastic plates, and we will describe how to obtain uniform rates of decay of the total energy associated with the above system. We will also discuss briefly the close relationship between the above system with some other classical models, such as the "modified von Kármán" (which is obtained when the in-plate displacements are not taken into account) and Timoshenko's equation for these plates. All above results were recently obtained in collaboration with J. Muñoz Rivera and E. Zuaza.

About some new results for the model of three-dimensional thermoelasticity

MICHAEL REISSIG
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Mathematics Subject Classification (1991): 73C99, 35B30

Our goal is to discuss new properties of the solutions for the following model of three-dimensional thermoelasticity:

$$U_{tt} + \mu\nabla \times (\nabla \times U) - \tau\nabla \text{div} U + \gamma\nabla\theta = f(U, \theta),$$

$$\theta_t - \kappa\Delta\theta + \gamma \,\text{div}\, U_t = g(U, \theta),$$

$$U(t = 0) = U_0, \quad U_t(t = 0) = U_1, \quad \theta(t = 0) = \theta_0.$$

• We show that under suitable conditions one can prove the propagation of so-called *mild singularities*, these are singularities which propagation picture is predicted by the linear system and coincides with that for classical wave operators.
• Moreover, we discuss the global existence in the case we have time-dependent coefficients $\mu = \mu(t)$, $\tau = \tau(t)$, $\gamma = \gamma(t)$, $\kappa = \kappa(t)$. One essential point to study the global existence of small data solutions is to derive $L_p - L_q$ decay estimates for the solutions of the corresponding linear problem. We want to explain the influence of the time-dependent coefficients on such estimates.

Backward uniqueness in linear thermoelasticity

Michael Renardy
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(coauthored with Irena Lasiecka and Roberto Triggiani)

Uniqueness of solutions backward in time is easily shown for problems which are well-posed backward in time, such as second order hyperbolic boundary value problems, and for problems associated with analytic semigroups, such as parabolic PDEs. On the other hand, backward uniqueness fails, for example, for first order hyperbolic boundary value problems. We establish a backward uniqueness result for the coupled hyperbolic-parabolic PDEs of linear thermoelasticity under covering all the usual boundary conditions. The abstract tool is an application of the Phragmen-Lindeloef theorem, which applies to all semigroups whose generators have a bounded resolvent along certain rays in the left half plane.

L_p Approach to the Ginzburg-Landau equations

Yoshihiro Shibata
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This is a joint work with Takahiro Akiyama (Waseda University).
We consider the Ginzburg-Landau equations in a three dimensional bounded domain. In the L_2 framework, we know the unique existence theorem by using Kato-Fujita like semigroup method. But, we need 3/4 regularity for the initital data. In order to avoid such regularity assumption on the initial data, we use the L_3 framework. Then, the main technical part is to solve the Stokes equations with some boundary condition in the L_p framework. In order to do that, we extend the Farwig-Sohr argument in the Dirichlet boundary condition case to our case.

On the Schauder estimate of solutions to elastostatic interface problems

SENJO SHIMIZU
(joint work with YOSHIHIRO SHIBATA)
Shizuoka University, Hamamatsu

Let Ω_1 and Ω_2 be bounded domains in $\mathbb{R}^3$ satisfying $\partial\Omega_1 = \Gamma_1$, $\partial\Omega_2 = \Gamma_1 \cup \Gamma_2$, $\Gamma_1 \cap \Gamma_2 = \emptyset$, and both the interface Γ_1 and the boundary Γ_2 is a compact hypersurface. Ω_1 (resp. Ω_2) is filled with an elastic material whose Lamé constants are λ_1 and μ_1 (resp. λ_2 and μ_2), and density is ρ_1 (resp. ρ_2).

We would like to report the L^p $(1 < p < \infty)$ estimate and the Schauder estimate of solutions to elastostatic interface problems. For the L^p estimate, we applied the Fourier multiplier theorem to the representation formula of solutions given in the appendix of Simader's Springer lecture note No. 268. For the Schauder estimate, first, we estimated the tangential direction by using the characterization of the Hölder space B^α by the Besov space $B^\alpha_{\infty,\infty}$. After this, we constructed the extension of the solution to the whole space and then, applying also the Besov space characterization of the Hölder estimate to the representation formula of this extension by using the Fourier transform, we obtained the desired Hölder estimate.

Chapman Enskog expansion

M. SLEMROD
University of Wisconsin-Madison, Madison

The Chapman Enskog expansion is a useful tool in kinetic theories of gases and polymers. It delivers partial differential equations for velocity, density, temperature which approximate the same quantities from the more fundamental kinetic theories. Unfortunately, the expansion has mathematical difficulties when used beyond Navier Stokes order. This talk will survey the relevant issues and discuss recent improvements by Shin Jin and Slemrod.

Microlocal analysis in semilinear thermoelasticity

YA-GUANG WANG
Shanghai Jiao Tong University, Shanghai

In this talk, we study the propagation of microlocal singularities for the one-dimensional semilinear thermoelastic system as follows:

$$\begin{cases} u_{tt} - \alpha^2(t,x)u_{xx} + \gamma(t,x)\theta_x = f(u, u_t, u_x, \theta) \\ \theta_t - \beta^2(t,x)\theta_{xx} + \gamma(t,x)u_{tx} = g(u, u_t, u_x, \theta) \end{cases} . \tag{1}$$

By using an idea similar to [1] and an uncoupling technique introduced in [2], we obtain the following result:

Theorem: *Let* Γ *be a null bicharacteristic of* $\partial_t^2 - \alpha^2(t,x)\partial_x^2$ *passing through* $(t_0, x_0; \tau_0, \xi_0)$. *For any fixed* $1 < s \leq r < 2s-1$, *if the solutions* $u \in H^{s+1}$ *and* $\theta \in H^s$ *of (1) satisfy*

$$u \in H_{ml}^{r+1}(t_0, x_0; \tau_0, \xi_0) \quad , \theta \in H_{ml}^{r-1}(t_0, x_0; \tau_0, \xi_0),$$

then we have

$$(u, \theta) \in H_{ml}^{r+1}(\Gamma),$$

where $H_{ml}^r(t_0, x_0; \tau_0, \xi_0)$ *is the space of functions* u *satisfying*

$$\chi_K(\tau, \xi)(1 + \tau^2 + \xi^2)^{\frac{r}{2}} \widehat{\phi u}(\tau, \xi) \in L^2(I\!R^2)$$

for certain $\phi \in C_0^\infty(I\!R^2)$ *with* $\phi(t_0, x_0) \neq 0$ *and* $K \subseteq I\!R^2$ *a conic neighborhood of* (τ_0, ξ_0), *and* $H_{ml}^r(\Gamma)$ *is the space of functions* $u \in H_{ml}^r(t, x; \tau, \xi)$ *for all* $(t, x; \tau, \xi) \in \Gamma$.

As a simple consequence, we have:

Corollary: *For any fixed* $s \geq 3$, *if the initial data for* (u, θ) *of (1) satisfy:*

$$(u, \theta)(0, \cdot) \in H^s(I\!R) \cap C^\infty(I\!R \setminus 0), \quad u_t(0, \cdot) \in H^{s-1}(I\!R) \cap C^\infty(I\!R \setminus 0),$$

then, there is $T > 0$ *such that*

$$(u, \theta) \in \cap_{\epsilon > 0} H_{loc}^{s+1-\epsilon}(\{0 < t < T, \ -\alpha t < x < \alpha t\}).$$

A similar result can be obtained for the semilinear thermoelastic system in three space variables.

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Unique global solvability and temporal asymptotics in one-dimensional thermoviscoelasticity

STEPHEN J. WATSON
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The lecture addresses the global solvability and temporal asymptotics of initial-boundary value problems for the equations of one-dimensional nonlinear thermoviscoelasticity. It considers a general and physically reasonable class of materials subject to a variety of boundary conditions. This includes the case of *pinned endpoints*. It presents results on global existence of smooth solutions for initial data of unrestricted size. Then, restricting attention to the *specified stress* boundary condition, it outlines results on the temporal asymptotics of solutions. A novel feature of the overall theory is that *solid-like* and *gaseous* materials are treated in a unified way.

Maximal attractors for the system of one-dimensional polytropic viscous ideal gas

SONGMU ZHENG[‡]
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This is a joint work with Y. Qin. The dynamics for the system of one-dimensional polytropic viscous ideal gas is investigated. One of important features of this problem is that the metric spaces $H^{(1)}$ and $H^{(2)}$ we work with are two incomplete metric spaces, as can be seen from the constraints $\theta > 0$ and $u > 0$ with θ and u being absolute temperature and specific volume, respectively. For any constants $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5$ satisfying certain conditions, two sequences of closed subspaces $H_\beta^{(i)} \subset H^{(i)}$ $(i = 1, 2)$ are found, and the existence of two maximal (universal) attractors in $H_\beta^{(1)}$ and $H_\beta^{(2)}$ are proved.

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