Book of Abstracts

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This volume includes the abstracts of contributions to Equadiff 11 - International conference on differential equations held in Bratislava, Slovakia, July 25–29, 2005. Abstracts are listed in the alphabetical order.

Many colleagues helped me to complete this volume. I especially thank Peter Guba – without his help the publication of this volume would not be possible.

Daniel Ševčovič
Bratislava, June 2005

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Book of Abstracts, Equadiff 11, International conference on differential equations held in Bratislava, Slovakia, July 25–29, 2005.

A Discontinuous Galerkin method for flow and transport

by *Vadym Aizinger and Clint Dawson*

In our talk, we will formulate a Discontinuous Galerkin method for flow and transport problems based on the Local Discontinuous Galerkin method of Cockburn and Shu (1998). The method uses locally defined approximation spaces that can be chosen independently on each element. A built-in upwinding mechanism insures stability and local conservation of mass in the scheme. To illustrate the performance of the method our presentation will include several numerical examples.

Infinitesimal Poincaré's return for saddle-connections

by *Clementa Alonso-González*

In this talk we classify multiple saddle-connections C of a real vector field over the skeleton K of a normal crossing divisor when a cycle with *infinitesimal return* appears on K.

The classification depends on the eigenvalues distribution and the Poincaré's maps associated to C.

A new approach to quasilinear parabolic problems

by *Herbert Amann*

We present a new existence, uniqueness, and continuity theorem for quasilinear parabolic evolution equations based on maximal regularity. As an application we show that simple and natural time regularization techniques yield well posed variants of ill posed forward–backward parabolic equations of Perona–Malik type occurring in image processing. In contrast to other regularization methods used so far, our approach, being local in space, does not introduce unwanted spatial disturbances.

Periodic solutions of dissipative systems revisited

by *Jan Andres*

It is well-known that, in the case of uniqueness, *dissipative* (in the sense of N. Levinson) *systems of ODEs in R^n, which are ω-periodic in time, possess ω-periodic solutions*. The standard proof is based on the application of the Browder fixed point theorem to the associated Poincaré's translation operator along the trajectories of a given system, and on the fact that dissipativity of time-periodic systems is uniform.

In our talk, we shall present at first a simple proof based on another asymptotic fixed point theorem. Then we shall also deal with a lower estimate of the number of (sub)harmonics (i.e. $k\omega$-periodic solutions, $k \in N$) and their localization by means of various (relative) Nielsen numbers for fixed and periodic points. Finally, we shall consider the situation in the lack of uniqueness.

Blow up in reaction-diffusion equations with nonlinear boundary conditions

by *José M. Arrieta and Aníbal Rodríguez-Bernal*

We analyze the existence of solutions that blow-up in finite time for the reaction diffusion equation $u_t - \Delta u = f(x, u)$ in a smooth domain Ω with nonlinear boundary conditions of the type $\partial u/\partial n = g(x, u)$. We show that, if locally around some point of the boundary, we have $f(x, u) = -\beta u^p$, $\beta \geq 0$, and $g(x, u) = u^q$ then, blow-up in finite time occurs if $2q > p + 1$ or if $2q = p + 1$ and $\beta < q$. This result complements others appearing in the literature and the following two possibilities are obtained for the case $f(x, u) = -\beta(x)u^p$, with some continuous function $\beta > 0$ and $\partial u/\partial n = u^q$, $p + 1 = 2q > 2$.

i) if $\beta(x) > q$ in $\partial\Omega$, then all solutions are global.

ii) if $\beta(x_0) < q$ for some $x_0 \in \partial\Omega$, then there exist solutions that blow-up in finite time.

Temporal and spatial decay rates of Navier–Stokes solutions in an exterior domain

by *Hyeong-Ohk Bae*

We show that the L^2 spatial-temporal decay rates of weak solutions of incompressible flow in an exterior domain. When a domain has a boundary, pressure term makes an obstacle since we do not have enough information on the pressure term near the boundary. In this paper, we give an idea which do not require any pressure information. We also estimated the spatial and temporal asymptotic behaviour for strong solutions.

Soluble surfactant spreading on a thin film

by *John W. Barrett*

We prove existence of a solution, via a fully practical finite element approximation, of the following system of nonlinear degenerate parabolic equations

$$
\begin{aligned}
&\tfrac{\partial u}{\partial t} + \tfrac{1}{2}\,\nabla.(u^2\,\nabla[\sigma(v)]) - \tfrac{1}{3}\,\nabla.(u^3\,\nabla w) = 0\,,\\
&w = -c\,\Delta u - \delta\,u^{-\nu} + \,a\,u^{-3}\,,\\
&\tfrac{\partial v}{\partial t} + \nabla.(u\,v\,\nabla[\sigma(v)]) - \tfrac{1}{2}\,\nabla.(u^2\,v\,\nabla w) - \rho_s\,\Delta v = K\,(\psi - v)\;,\\
&\tfrac{\partial \psi}{\partial t} + \tfrac{1}{2}\,u\,\nabla[\sigma(v)].\nabla\psi - \tfrac{1}{3}\,u^2\,\nabla w\,.\nabla\psi - \rho_b\,u^{-1}\,\nabla.\,(u\nabla\psi) = \beta\,K\,u^{-1}\,(v-\psi)\;.
\end{aligned}
$$

The above equations model a Marangoni driven thin film laden with a soluble surfactant, in which the bulk surfactant concentration has been vertically averaged. The model accounts for the presence of both attractive, $a \geq 0$, and repulsive, $\delta > 0$ with $\nu > 7$, van der Waals forces. Here u is the height of the film, v is the concentration of the interfacial surfactant species, ψ is the concentration of the surfactant species within the bulk phase and $\sigma(v) := 1 - v$, the typical surface tension, is dependent on interfacial quantities only. Moreover, $\rho_s > 0$, $\rho_b > 0$ and $c > 0$ are the inverses of the surface Peclet number, the bulk Peclet number and the modified capillary number respectively; finally, $\beta > 0$ and $K > 0$ are parameters that characterise the solubility and the rate of interfacial adsorption.

Nodal solutions of semilinear elliptic equations

by *Thomas Bartsch*

We report on recent work concerning the multiple existence and shape of nodal solutions of the equation $-\Delta u = f(x,u)$ on a bounded domain in $\mathbb{R}^N$ with Dirichlet boundary conditions.

A monotone Eulerian–Lagrangian localized adjoint scheme for convection-dominated transport

by *Peter Bastian*

Eulerian–Lagrangian Localized Adjoint Methods (ELLAMs) are characteristic-type methods based on a weak formulation in space-time. Approximate evaluation of certain key integrals, which is necessary in multiple space dimensions, leads to non-conservative schemes in the case of backward tracking and to non-monotone but conservative solutions in the case of forward tracking.

In this joint work with Thimo Neubauer the different reasons for oscillations in ELLAM schemes are identified. Then a purely algebraic approach is presented that modifies the forward tracking method applied to a finite-volume ELLAM in such a way that it satisfies a discrete maximim principle. Numerical results illustrating the convergence bahavior and the ability to handle unstructured meshes as well as highly non-uniform flow fields are given.

Periodic solutions of symmetric elliptic singular systems

by *Flaviano Battelli and Michal Fečkan*

We study the problem of existence of periodic solutions to certain singularly perturbed systems having symmetry properties that bifurcate from a homoclinic orbit of the degenerate equation, when the centre manifold is not normally hyperbolic. Our result applies to some singular systems arising in the study of Hamiltonian systems with a strong restoring force.

Finite element methods for free surface flow

by *Eberhard Bänsch*

In practical flow computations, boundary conditions play a major role in order to appropriately model certain physical situations. Often these conditions turn out to be free boundary conditions involving surface tension. Among others, one may think of applications like flows in semi-conductor melts, falling films, flow problems under microgravity and many more.

In the talk we present a finite element method to effectively address these types of problems.

Interestingly, it turns out that the approach is also applicable in totally different fields of physics, for instance to describe morphological changes of epitaxial thin films governed by surface diffusion.

Quasilinear problems of the $2n^{\text{th}}$-order

by *Jiří Benedikt*

We study ordinary differential equations of the type

$$(-1)^n\big(a\,|u^{(n)}|^{p-2}u^{(n)}\big)^{(n)} = b\,|u|^{q-2}u$$

where $n \in \mathbb{N}$, $p, q > 1$, and $a > 0$. Equivalently,

$$\begin{aligned} u^{(n)} &= a^{-1/(p-1)}|v|^{1/(p-1)}\operatorname{sgn} v,\\ v^{(n)} &= (-1)^n b\,|u|^{q-1}\operatorname{sgn} u. \end{aligned}$$

If $p \le q$ (i.e. $\alpha\beta \ge 1$ where $\alpha = 1/(p-1)$ and $\beta = q-1$), then the corresponding initial value problem has at most one solution. Consequently, the zero initial conditions lead to the trivial solution only. In terms of the oscillation theory, every nontrivial solution defined on $[t_0, \infty)$ is proper. In the opposite case, $p > q$, we have a counterexample.

On the other hand, if $p \ge q$ ($\alpha\beta \le 1$), the initial value problem possesses at least one globally defined solution. Otherwise the solution can "blow-up".

These results allow us to prove basic spectral properties of boundary value problems for

$$(-1)^n\big(|u^{(n)}|^{p-2}u^{(n)}\big)^{(n)} = \lambda|u|^{p-2}u.$$

Choosing $n = 1$ and $n = 2$, the operator on the left-hand side is called the (one-dimensional) p-Laplacian and p-biharmonic operator, respectively.

Quantitative aspects of microstructure formation in solidification

by *Michal Beneš*

The growth of microstructure non-convex patterns is studied by means of the modified anisotropic phase-field model. The numerical algorithm is designed using the finite-difference spatial discretisation in the method of lines. Beside the numerical analysis of the model which is using the a-priori estimates and the compactness and monotonicity arguments, we present a series of qualitative studies demonstrating ability of the model. A special attention is paid to the implementation issues such as handling of high CPU-cost parts of the code and parallelization. As a quantitative result, we present the convergence studies when mesh size and diffuse parameter tend to zero.

Nonlinear oscillations in Hamiltonian PDEs

by *Massimiliano Berti*

We present new existence results of periodic and quasi-periodic solutions of completely resonant nonlinear Hamiltonian PDEs. We consider both free and forced vibrations problems. Both infinite dimensional bifurcation problems and small divisors difficulties occur. The proofs require the use of bifurcation theory, variational methods, Nash-Moser implicit function theorems.

On the dynamics of multi-component heat-conducting incompressible plane flow with temperature dependent viscosity

by *Arup Bhattacharjee*

We consider the initial boundary value problem which governs the dynamics of multi-component heat-conducting incompressible plane flow in case the coefficients of viscosity and heat conductivity depend on temperature. The components of the fluid are separated by unknown interfaces which need to be found. We apply the method of Maslennikova V. N. and Bogovskii M. E. which, in a few words, can be described as the 'Euler type' method involving the so called pseudo-density function $F(x,t)$, artificially introduced to describe the interface implicitly by the equation $F(x,t) = 0$, where the function $F(x,t)$ is determined as the solution of the Cauchy problem for the transport equation. Given viscosity and heat conductivity coefficients being arbitrary Lipschitz functions in temperature, we establish the existence of a global weak solution of the posed problem on any time interval without any smallness assumptions imposed on the appropriate norms of initial data, densities of external forces and heat sources. The weak solution is in the anisotropic Sobolev space $W_{2,x,t}^{1,1/2}$ with fractional order smoothness of $1/2$ in time variable t. Our approach underlies as well an effective algorithm for the numerical approximation of global weak solutions of the initial boundary value problem under consideration, which governs the dynamics of the multi-component heat-conducting viscous incompressible plane flow.

Dynamical systems in artificial neural networks

by *Andrzej Bielecki*

The theory of dynamical systems is often used as a model of a multi-layer neural networks learning process. Most of them are iterative processes. One of the possible approaches to analysis of these processes is to consider differential equations such that the actual iterative procedure is a numerical method applied to this equation. A gradient differential equation is an example of a proper one for such analysis. Theorems about topological conjugacy between discretization of the flow generated by the differential equation and the cascade generated by a numerical method applied to this equation can be used for analysis of properties of the learning process. It can be also shown that sometimes learning process has a shadowing property.

On qualitative and quantitative mathematical models for diffusion induced segregation processes

by *Thomas Blesgen*

Diffusion Induced Segregation is a particular phenomenon in mineralogy where the segregation only starts after the concentration of a diffusor penetrating the solid from outside exceeds a certain threshold. In a first step, based on a thermodynamical description, a system of partial differential equations is derived to model the process. Existence and uniqueness of weak solutions are shown. Furthermore, by ab initio methods, the actual free energies of the physical process are approximated and used to perform high-precision finite-element computations.

Stochastic modulation equations

by *Dirk Blömker*

We consider as an example the Swift–Hohenberg equation on large (but still bounded) domains near a change of stability. This equation is a toy model for the Rayleigh–Benard convection. It is well known that sufficiently close to the bifurcation, solutions can be approximated by a periodic wave, which is modulated by the solutions of a Ginzburg–Landau equation.

Noise, for instance induced by thermal fluctuations, is natural for physical models like these. We discuss how noise in the equation effects the approximation, and give rigorous error estimates in the stochastic case. This approximation also extends to long time behaviour given by invariant measures, and has applications in pattern formation below the threshold of instability.

[1] D. Blömker, M. Hairer, G. A. Pavliotis. Modulation Equations: Stochastic Bifurcation in Large Domains, Comm. Math. Phys., to appear.

Some properties of the quasilinear analogues of the Hill's equation

by *Gabriella Bognár*

We consider the quasilinear analogues of the Hill's equation

$$x'' |x'|^{p-1} + b(t) x |x|^{p-1} = 0. \tag{1}$$

If $p = 1$ the differential equation is called Hill's equation.

For any given initial condition at $t_0 \in I$

$$x(t_0) = x_0, \quad x'(t_0) = x_0'$$

there exists a unique solution $x(t)$ defined for all $t \in I$. Various concepts intrinsically defined by the differential equation, are interpreted geometrically by concepts analogous to those in Minkowski plane.

We investigate the qualitative properties of solutions to (1).

If (1) has two different periodic solutions $x_1(t), x_2(t)$ then we give some properties for curve $[x_1(t), x_2(t)]$ called indicatrix.

A set of bounded solutions for perturbed differential and difference systems

by *Alexander A. Boichuk*

A weakly perturbed linear inhomogeneous systems

$$\dot{x} = A(t)x + \varepsilon A_1(t)x + f(t), \quad A(t), A_1(t), f(t) \in BC(R), \tag{1}$$

are considered for arbitrary $f(t) \in BC(R)$ and in the assumption that the generation homogeneous system

$$\dot{x} = A(t)x \tag{2}$$

is an exponential dichotomous on $R_+ = [0, +\infty)$ and $R_- = (-\infty, 0]$ [1]. It is shown that if $rank \int_{-\infty}^{\infty} H_d^*(\tau)A_1(\tau)X_r(\tau)d\tau = d$, then system (1) has exactly ρ–parametric set of linearly independent solutions bounded on the entire real axis $R = (-\infty, +\infty)$, where: $\rho = r - d;$ $X_r(t)$ is an $n \times r -$ $\{ H_d^*(t) - d \times n- \}$ matrix whose columns $\{$ rows $\}$ form a complete family of r $\{ d \}$ linear independent solutions bounded on R of system $\{$ conjugate to system $\}$ (2). Similarly results for difference systems are discussed [2].

[1] R. J. Sacker The splitting index for linear differential systems, *J. Differential Eq.* **33** (1979), 368–405.

[2] A. A. Boichuk and A. M. Samoilenko (2004), Generalized Inverse Operators and Fredholm Boundary Value Problems, *VSP, Utrecht–Boston*, p. 317.

Shadowing collision chains of the 3 body problem

by *Sergey Bolotin*

We consider the plane restricted elliptic 3 body problem with small masses ratio and small eccentricity and prove the existence of many periodic and chaotic orbits shadowing chains of collision orbits of the Kepler problem. Such periodic orbits were first studied by Poincaré who named them second species solutions. The proofs are based on variational methods.

Computing homoclinic orbits for maps with Bogdanov–Takens point

by *Imre Bozi*

We consider a mapping of the form

$$f : \mathbf{R}^2 \times \mathbf{R}^2 \to \mathbf{R}^2 \ , \quad (x, \alpha) \to f(x, \alpha)$$

with a so-called Bogdanov-Takens point $(\overline{x}, \overline{\alpha}) \in \mathbf{R}^2 \times \mathbf{R}^2$ (implying that $f(\overline{x}, \overline{\alpha}) = \overline{x}$ and $D_x f(\overline{x}, \overline{\alpha})$ has a double 1 eigenvalue). Our aim is to compute homoclinic orbits by looking for solutions of the system of nonlinear equations

$$x_{n+1} = f(x_n, \alpha) \ , \quad n = n_-, \ldots, n_+ - 1 \ , \qquad b(x_{n_-}, x_{n_+}) = 0$$

where b denotes the projection boundary condition. We apply Newton's method first to the normal form and then to the general case. Convergence results are presented.

Diffpack - A flexible development framework for the numerical modeling and solution of partial differential equations

by *Peter Böhm and Frank Vogel*

The Diffpack Development Framework, developed by inuTech GmbH, is an object-oriented software environment for the numerical solution of partial differential equations (PDEs). Diffpack is used world-wide for research and development purposes in industry as well as in the academic sector. By its design, Diffpack intend to close the gap between black-box simulation packages and technical computing environments using interpreted computer languages. The framework provides a high degree of modeling flexibility, while still offering the computational efficiency needed for most demanding simulation problems in science and engineering. Technically speaking, Diffpack is a collection of C++ libraries with classes, functions and utility programs. The numerical functionality is embedded in an environment of software engineering tools supporting the management of Diffpack development projects. Diffpack supports a variety of numerical methods with distinct focus on the finite element method (FEM) but has no inherent restrictions on the types of PDEs and therefore applications to be solved. The presentation addresses the key features of the development framework: (1) Providing high efficiency in constructing a self-programmed application software. (2) Giving high and flexible modeling power to build, change and reuse software solving your physical problems. (3) Ensuring computational efficiency of your application. This is achieved by a software design based on a strict object-oriented software approach, combining the advantages of code reuse and extensibility with the robustness acquired through long-time versatile use. It is in particular designed to allow easy modification and combination of almost all available numerical building blocks making up an application. This results in shorter development time and cleaner code that is easier to maintain. In addition minor C++ knowledge is required to get started. The well-known computational bottle-neck of object-oriented programming languages is avoided by performing low-level, computational intensive operations on a C-type level. Efficiency is further enhanced by providing easy to combine state-of-the-art numerical functionalities, like adaptive methods, multilevel methods, generalized (mixed) finite element methods and domain decomposition methods. As an example, the high flexibility of the software package is demonstrated by considering numerical requisites and the corresponding software realization for solving electromagnetic field problems by the finite element method. In particular this includes the integration of non-standard vector-valued finite element basis functions to a software environment which is strictly based on the use of scalar quantities.

Conservation laws and related equations with discontinuous flux modeling clarifier-thickener units

by *Raimund Bürger*

We formulate and partly analyze a new mathematical model for continuous sedimentation–consolidation processes of flocculated suspensions in clarifier-thickener units. This model appears in two variants for cylindrical and variable cross-sectional area units, respectively (Models 1 and 2). In both cases, the governing equation is a scalar, strongly degenerate parabolic equation in which both the convective and diffusion fluxes depend on parameters that are discontinuous functions of the depth variable. The initial-value problem for this equation is analyzed for Model 1. We introduce a simple finite-difference scheme and prove its convergence to a weak solution that satisfies an entropy condition. A limited analysis of steady states as desired stationary modes of operation is performed. Numerical examples illustrate that the model realistically describes the dynamics of flocculated suspensions in clarifier-thickeners. Finally, recently developed second-order schemes for the model are reviewed.

This presentation is based on joint work with Kenneth H. Karlsen (Oslo) and John D. Towers (Cardiff-by-the-Sea, USA).

Positive solutions of the logistic elliptic BVP with nonlinear mixed boundary conditions of logistic type

by *Santiago Cano-Casanova*

We are going to analyze the structure of the global bifurcation diagram of positive solutions of the following Logistic elliptic BVP with nonlinear mixed boundary conditions of logistic type given by

$$\begin{cases} \mathcal{L}u = \lambda u - a(x)u^p & \text{in } \Omega,\ p>1, \\ u = 0 & \text{on } \Gamma_0, \\ \partial_\nu u - V(x)u + b(x)u^q = 0 & \text{on } \Gamma_1,\ q>1, \end{cases}$$

where we make the following assumptions:
(a) The domain Ω is a bounded domain of $\mathbf{R}^N, N \geq 1$, of class $\mathcal{C}^2$, whose boundary $\partial\Omega = \Gamma_0 \cup \Gamma_1$, where Γ_0 and Γ_1 are two disjoint open and closed subset of $\partial\Omega$.
(b) $\lambda \in \mathbf{R}$ is the bifurcation parameter and $\mathcal{L}$ stands for a linear second order differential operator of the form $\mathcal{L} := -\sum_{i,j=1}^N \alpha_{ij}(x)\frac{\partial^2}{\partial x_i \partial x_j} + \sum_{i=1}^N \alpha_i(x)\frac{\partial}{\partial x_i} + \alpha_0(x)$; which is uniformly strongly elliptic in Ω with $\alpha_{ij} = \alpha_{ji} \in \mathcal{C}^1(\bar{\Omega}), \quad \alpha_i \in \mathcal{C}(\bar{\Omega}), \quad a_0 \in L_\infty(\Omega), \quad 1 \leq i,j \leq N$.
(c) The potentials $a(x) \in L_\infty(\Omega)$ is a nonnegative bounded measurable real weight function in Ω for which there exists an open subset Ω_a^0 of Ω of class $\mathcal{C}^2$ satisfying dist $(\Gamma_1, \partial\Omega_a^0 \cap \Omega) > 0$, such that $a = 0$ in Ω_a^0, $b(x) \in \mathcal{C}(\Gamma_1)$ is a positive function on Γ_1 which is bounded away from zero on $\Gamma_1 \cap \partial\Omega_a^0$ and $V(x) \in \mathcal{C}(\Gamma_1)$ is a positive function on Γ_1. Finally $\nu := (\nu_1, \ldots, \nu_N) \in \mathcal{C}^1(\Gamma_1; \mathbf{R}^N)$ is the *conormal field* on Γ_1 and $\partial_\nu u := \langle \nabla u, \nu \rangle$.

Also, we will show some numerical results obtained for the scalar case.

Compact convergence and continuity of attractors

by *Alexandre N. Carvalho*

Our aim is to present a general scheme to obtain continuity of attractors for semilinear parabolic problems. This scheme has been applied to study the continuity of attractors for parabolic problems of the form

$$u_t = \text{div}(a\nabla u) + f(u), \quad \text{in } \Omega$$
$$+ \text{ linear boundary conditions}$$

with respect to a, Ω, f (Ω is a bounded smooth domain in $\mathbb{R}^N$) and to spatial discretization. The idea is to prove continuity of attractors from the continuity of the resolvent of the linear part of the equation.

Switched systems, discontinuous ODE's and Zeno phenomenon

by *Francesca Ceragioli*

This talk deals with some theoretical issues motivated by the recent engineering literature about switched systems. Roughly speaking, a switched system is given by a family of vector fields together with a rule which governs switching among them. Admissible rules are in general subject to some constraints: for instance, jumps from one vector field to another cannot arise too quickly. If jumps accumulate in finite time, Zeno phenomenon is said to occur. Here we investigate the case switching rules only depend on the state of the system. In the classical mathematical control theory, such switching rules are interpreted as discontinuous feedback laws. These, when implemented, give rise to systems with discontinuous righthand sides, whose solutions have to be intended in some generalized sense. We motivate our opinion that piecewise classical solutions are the ones which fit better in this context. The major drawback of this approach is that there are very few results in the literature about existence, uniqueness, continuability of these solutions: we contribute with a simple result in this direction. Then we remark that, even if solutions are considered in the piecewise classical sense, the implementation of state dependent switching rules may result in the occurrence of Zeno phenomenon and we give some conditions which allow to exclude it.

Necessary optimality conditions for differential-difference inclusions via derived cones

by *Aurelian Cernea*

We study an optimal control problem given by differential-difference inclusions with endpoint constraints. We prove that the reachable set of a certain variational inclusion is a derived cone in the sense of Hestenes to the reachable set of the differential-difference inclusion. This result allows to obtain a simple proof of the Maximum Principle for optimal control problems given by differential-difference inclusions with endpoint constraints and sufficient conditions for local controllability along a reference trajectory.

Comparison of analytical and numerical results for the p-Laplace equation

by *Jan Čepička*

We present numerical experiments applied to problems with p-Laplace operator $u \to \Delta_p u = \operatorname{div}(|\nabla u|^{p-2}\nabla u)$, $p > 1$. The periodical and Dirichlet boundary value problems are investigated. We study the existence of solutions and their structure. Numerical results are compared with literature results and calculated bifurcation diagrams can be useful for p-Laplace operator study and for non-linear Fredholm alternative description as well.

Approximation of the anisotropic or crystalline curvature flow

by *Antonin Chambolle*

We will present some algorithms for computing the anisotropic or crystalline curvature flow of a set. We will sketch new proofs of consistency for these algorithms, and discuss the numerical implementation. This is joint work with Matteo Novaga, and, in part, Giovanni Bellettini and Vicent Caselles.

On the growth rate of blowup solutions of some semilinear and quasilinear equations of parabolic type

by *Manuela Chaves*

In this talk we are interested in the blowup solutions of some semilinear and quasilinear equations of parabolic type. The results we present, deal with the bound of the growth rate as well as a characterization of the asymptotic behaviour of the solutions near blow-up. We show the main features and difficulties that appear when dealing with these problems for different second order and higher order equations.

Invariant manifolds and almost automorphic solutions of second-order monotone equations

by *David Cheban and Cristiana Mammana*

We give sufficient conditions of the existence of a compact invariant manifold, almost periodic (quasi-periodic, almost automorphic, quasi-recurrent) solutions and chaotic sets of the second-order differential equation $x'' = f(t, x)$ on an arbitrary Hilbert space with the uniform monotone right hand side f.

Semilinear parabolic equations with critical nonlinearities

by *Jan W. Cholewa*

Continuation properties and asymptotic behavior of ε-regular solutions to abstract semilinear parabolic problems are discussed based on the joint publication [2] in case when the nonlinear term satisfies certain critical growth conditions. Piecewise smooth ε-regular solutions, which are right-hand continuations of non globally defined ε-regular solutions are also considered and applications to strongly damped wave equations and to higher order semilinear parabolic equations are described.

[1] J. M. Arrieta, A. N. Carvalho, Abstract parabolic problems with critical nonlinearities and applications to Navier–Stokes and heat equations, Trans. Amer. Math. Soc. 352 (2000), 285-310.

[2] A. N. de Carvalho, J. W. Cholewa, Continuation and asymptotics of solutions to semilinear parabolic equations with critical nonlinearities, J. Math. Anal. Appl., to appear.

[3] W. von Wahl, Global solutions to evolution equations of parabolic type, Lecture Notes in Math., 1223, Springer, Berlin, 1986, 254-266.

A semilinear Birkhoff–Kellogg theorem and application

by *Casey T. Cremins*

A fixed point index for semilinear operators is used to prove a Birkhoff–Kellogg type result for semilinear equations. An application to a second order boundary value problem is then given to illustrate the theory.

Generalized solutions of mixed problems for first order partial functional differential equations

by *Wojciech Czernous*

A theorem on the existence and continuous dependence upon initial boundary conditions is proved. The method of bicharacteristics is used to transform the mixed problem into a system of integral functional equations of the Volterra type. The existence of solutions of this system is proved by a method of successive approximations and by using theorems on integral inequalities. Classical solutions of integral functional equations lead to generalized solutions of the original problem. Differential equations with deviated variables and differential integral problems can be obtained from a general model by specializing given operators.

Numerical modeling of the simultaneous heat and moisture transport in porous materials

by *Josef Dalík*

In this contribution, we present an original mathematical model of the heat and moisture transport in porous materials. This model consists of two highly non-linear partial differential equations of second order. We present results of numerical modeling illustrating essential properties of this process on one hand and the ability of the model to give physically relevant results in different extreme situations on the other hand. Among others, these extreme situations include presence of high amounts of moisture as well as presence of moisture in all phases in the porous structure. The state of the art of the mathematical analysis of this model will be described, too.

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A remark on Morrey type regularity for nonlinear elliptic systems of second order

by *Josef Daněček & Eugen Viszus*

In this paper we discuss the problem of the regularity of the gradient of weak solutions to nonlinear elliptic systems

$$-D_\alpha a_i^\alpha(x, Du) = 0, \quad i = 1, \dots, N,$$

where the coefficients $a_i^\alpha(x, Du)$ have some special form and they may be discontinuous in general.

Sums of free membrane eigenvalues

by *Bodo Dittmar*

Let D be a simply connected domain in the plane. We consider the following classical eigenvalue problem

$$\begin{aligned} \Delta v + \mu v = 0 \quad &\text{in} \quad D, \\ \frac{\partial v}{\partial n} = 0 \quad &\text{on} \quad \partial D, \end{aligned}$$

which has countably many eigenvalues with finite multiplicity

$$\mu_1 = 0 < \mu_2 \leq \mu_3 \ldots$$

and corresponding eigenfunctions. Each eigenvalue is counted as many times as its multiplicity. The aim of the talk is the proof that for any $n \geq 2$

$$\sum_2^n \frac{1}{\mu_j} \geq \frac{\pi}{A} \sum_2^n \frac{1}{\mu_j^{(o)}},$$

where A is the area of the domain D and $\mu_j^{(o)}$ are the free membrane eigenvalues of the unit disk. Equality occurs if and only if D is the unit disk (Dittmar, Math. Nachr. 2002, Journal d' Analyse 2005, Handbook of Complex Analysis: Geometric Function Theory, Volume 2, Elsevier 2005, Chapter 16).

For the fixed membrane problem a similar result was proven by Pólya and Schiffer in 1955.

Strongly damped wave equation in uniform spaces

by *Tomasz Dlotko*

Cauchy problem in R^n for a semilinear strongly damped wave equation:

$$u_{tt} - \alpha\Delta u_t - \Delta u + \beta u_t = f(u) + g(x),\ x \in R^n,\ t > 0, \tag{1}$$

is considered in [2] with subcritical f growing like $|u|^q$ with $q < \frac{n+2}{n-2}$ for $n \geq 3$. To assure the decay of linear semigroup connected with (1) we need the positive constants α, β to satisy $\alpha\beta \geq 1$. The nonlinear term f is *dissipative*:

$$\exists_{k\geq 1,\ \sigma>0,\ C_\sigma \in R}\ \forall_{s\in R}\ sf(s) - kF(s) \leq -\sigma s^2 + C_\sigma \text{ and } \exists_{C'>0}\ \forall_{s\in R}\ F(s) \leq C',$$

where $F(s) = \int_0^s f(z)dz$. Global in time solvability of (1) in *locally uniform spaces* ([1]) $\dot{W}^{2,p}_{lu}(R^n) \times \dot{L}^p_{lu}(R^n)$, $p \geq 2$, $p > \frac{n}{2}$, and existence of the *two–spaces global attractor* $\mathcal{A}$ is shown. This attractor is bounded in $\dot{W}^{1,p}_{lu}(R^n) \times \dot{W}^{1,p}_{lu}(R^n)$, invariant, compact in the weight space $W^{1,p}_\rho(R^n) \times W^{1,p}_\rho(R^n)$ and attracts bounded subsets of $\dot{W}^{2,p}_{lu}(R^n) \times \dot{L}^p_{lu}(R^n)$.

[1] J. Arrieta, J. W. Cholewa, T. Dlotko, A. Rodriguez-Bernal, Linear parabolic equations in locally uniform spaces, *Math. Models Methods Appl. Sci.* 14 (2004), 253-294.

[2] J. W. Cholewa, T. Dlotko, Strongly damped wave equation in uniform spaces, submitted.

Spectral properties of non-local operators

by *N. Dodds and F. A. Davidson*

Spectral properties of a non-local partial differential operator are considered. The operator studied is a bounded perturbation of a linear local partial differential operator. The non-local perturbation is in the form of an integral term, and the domain of the operator incorporates suitable boundary conditions. This non-local equation could arise as the linearization of a non linear non-local equation, as found in Ohmic heating, population dynamics and combustion theory. Therefore, the spectrum of such equations is significant for the stability of steady states of such non-local equations. We consider under what restrictions on the form of the linear non-local operator, do the well known spectral properties of a 2nd order uniformly elliptic differential operator, hold for the non-local operator. Bifurcation theory is then used to deduce the existence of non-trivial steady states of these non linear non-local equations.

Oscillation properties of functional equations in spaces of functions of several variables

by *Alexander Domoshnitsky*

Analysis of oscillation properties of functional equations is reduced to estimates of the spectral radius of corresponding operators in the space of the essentially bounded functions. Zeros of functions in this space are defined. The upper estimates of the spectral radius lead us to nonoscillation, and the lower estimates to oscillation of solutions. Assertions estimating the spectral radius are obtained in the form of theorems about functional inequalities. Various tests of oscillation/nonoscillation are proven on this basis. Several known tests of oscillation/nonoscillation for the functions of one variable follow from our results. Various comparison theorems are proposed. Zones of positivity of solutions are estimated. Applications of these results to the problem of positivity solutions of the Dirichlet problem for partial differential equations are proposed.

Principal solution of half-linear second order differential equations

by *Ondřej Došlý*

The principal solution of the nonoscillatory half-linear second order differential equation

$$(*)\qquad (r(t)\Phi(x'))' + c(t)\Phi(x) = 0, \quad \Phi(x) := |x|^{p-2}x,\ p > 1,$$

is an important concept of the qualitative theory of (*). In the linear case $p = 2$, the properties and various characterizations of the principal solution are well known. In the general case $p \neq 2$, since the additivity of the solution space is lost and only homogeneity remains, the investigation of the principal solution of (*) is an interesting problem.

We are going to present recent results of this investigation, in particular, the limit and integral characterization of the principal solution of (*) will be discussed.

The p-Laplacian – mascot of nonlinear analysis

by *Pavel Drabek*

The p-Laplacian became very popular second order quasilinear differential operator in order to illustrate both the similarities and the differences between the linear and nonlinear theory. Hundreds of papers have appeared during the past 20 years which contain this operator as a principal part of various kinds of boundary value problems. Most authors demonstrate how to extend the results known for semilinear problems to quasilinear ones. On the other hand there are few results which show the striking differences between these two cases. Our talk will focus on the latter phenomena. In particular, we concentrate on the behavior of the p-Laplace operator near its first eigenvalue. We will discuss the bifurcation from the first eigenvalue, the Fredholm alternative-type results at the first eigenvalue and Landesman–Lazer type problems at any eigenvalue.

Bifurcation of relaxation oscillations

by *Freddy Dumortier*

The talk deals with bifurcation of relaxation oscillations in two-dimensional systems, with emphasis on Liénard equations. Attention goes to the investigation of the transient canard oscillations during the bifurcation as well as to the techniques used in proving the results. The talk relies on recent joint work with Robert Roussarie.

Asymptotic properties of third order differential equations with deviating arguments

by *Jozef Džurina*

We shall discuss asymptotic properties of the third order binomial differential equations with deviating argument of the form

$$y'''(t) \pm p(t)y'(t) + q(t)y(\tau(t)) = 0. \tag{1}$$

Employing Trench's theory of canonical operators we are able to rewrite equation (1) into binomial form. Then using suitable comparison theorems we can study properties of equation (1) with help of differential equations without deviating argument. So desirable generalizations of some known oscillation criteria from equations without deviating argument to equation (1) become immediate.

Critical points at infinity and blow up of solutions of autonomous polynomial differential systems

by *U. Elias and H. Gingold*

We consider an autonomous system of differential equations

$$\mathbf{y}' = \mathbf{f}(\mathbf{y}), \quad \mathbf{y} \in R^n,$$

where $f_i(y_1, \dots y_n)$ are polynomials. Compactification of the space R^n by addition of points at infinity and mapping them into finite points is frequently used in the study of critical points at infinity. We consider various direction preserving bijections from R^n to the unit ball of the form

$$\mathbf{x} = \mathbf{y}/\kappa(\mathbf{y}), \qquad \kappa(\mathbf{y}) = \kappa(y_1, \dots, y_n) > 0,$$

which transform our system into

$$\frac{d\mathbf{x}}{dt} = \kappa^{-1}(\mathbf{y}(\mathbf{x}))\Big[\mathbf{f}(\kappa\mathbf{x}) - \langle \nabla\kappa, \mathbf{f}(\kappa\mathbf{x})\rangle\, \mathbf{x}\Big].$$

This is utilized to characterize a critical point at infinity in the direction $\mathbf{p}$ and to study the rate of blow up of solutions which tend to such critical point.

Finite elements and evolving surfaces

by *Charlie Elliott*

In this talk we define a new evolving surface finite element method (ESFEM) for the numerical approximation of partial differential equations on hypersurfaces $\Gamma(t)$ in $\mathbb{R}^{n+1}$ which evolve with time. The key idea is based on approximating $\Gamma(t)$ by an evolving interpolated polyhedral (polygonal if $n = 1$) surface $\Gamma_h(t)$ consisting of a union of simplices (triangles for $n = 2$) whose vertices lie on $\Gamma(t)$. A finite element space of functions is then defined by taking the set of all continuous functions on $\Gamma_h(t)$ which are linear affine on each simplex. The finite element nodal basis functions enjoy a remarkable transport property which simplifies the computation. We formulate a conservation law for a scalar quantity on $\Gamma(t)$ and derive a transport and diffusion equation which takes into account the tangential velocity of the surface and the local expansion or contraction. Using surface gradients to define weak forms of elliptic operators naturally generates a finite element approximation of elliptic and parabolic equations on $\Gamma(t)$. The computation of the mass and element stiffness matrices are simple and straightforward. Error bounds are derived in the case of semi-discretization in space. Numerical experiments are described which indicate the order of convergence and also the power of the method. We describe how this framework may be employed in applications.

This is joint work with G. Dziuk (Freiburg).

Uniqueness/nonuniqueness for positive solutions to a class of semilinear equations

by *Janos Englander*

Uniqueness/nonuniqueness for positive solutions to semilinear equations of the form $u_t = Lu + Vu - \gamma u^P$ in R^n is studied. Connection to linear equations, steady state solutions and stochastic processes is investigated.

This is joint work with Ross G. Pinsky (Technion).

Finite volumes schemes for nonlinear parabolic problems: a regularization method

by *Robert Eymard*

Finite volume schemes have been shown to be very efficient for the simulation of some nonlinear degenerate parabolic equations, such as those which arise in the framework of multiphasic flows in porous media or american options in financial mathematics. A reason of this fact is that a finite volume scheme acts as a regularizer of the problem, permitting to simultaneously take into account parabolic degenerate terms and nonlinear convective terms. This lecture will review the different mathematical results which explane the analogy between letting the size of the discretization tend to zero and letting the regularization of the degenerate equation tend to zero.

Suitable weak solutions of the Navier–Stokes equations in arbitrary unbounded domains

by *Reinhard Farwig*

In order to prove partial regularity results of so-called suitable weak solutions of the instationary Navier–Stokes system three basic linear estimates of the Stokes system, namely

- the existence of the Helmholtz decomposition in L^q, $q \neq 2$,
- the Stokes resolvent estimates in L^q, $q \neq 2$,
- the maximal regularity of the instationary Stokes system,

are fundamental. Unfortunately, there are counter-examples that in some unbounded domains the Helmholtz decomposition in L^q fails to exist.

In this talk, a joint work with H. Sohr (Paderborn) and H. Kozono (Tohoku Univ., Sendai), we present a new approach to deal with this basic linear theory in an arbitrary unbounded (uniform C^2–) domain Ω and to prove the existence of suitable weak solutions as well as the strong energy inequality. The main idea is to start with L^2–theory and to replace the classical L^q space by the space

$$\tilde{L}^q(\Omega) = \begin{cases} L^2(\Omega) \cap L^q(\Omega), & 2 \leq q < \infty \\ L^2(\Omega) + L^q(\Omega), & 1 < q < 2 \end{cases} .$$

Existence and impulsive stability for second order retarded differential equations

by *L. P. Gimenes and M. Federson*

We generalize the results of Xiang Li and Peixuan Weng (2004) and prove the existence and impulsive stability of solutions for the following second order delay differential equations

$$\begin{cases} x''(t) + \sum_{i=1}^{N} a_i(t)\, x(t-\tau_i) + f(x(t), x'(t)) = 0, \quad t \geq t_0 \\ x(t) = \varphi(t), \quad t_0 - \tau_N \leq t \leq t_0 \\ x'(t_0) = y_0 \end{cases} \tag{1}$$

and

$$\begin{cases} x''(t) + \sum_{i=1}^{N} \int_{t-\tau_i}^{t} b_i(t-u)x(u)du = r(t), \quad t \geq t_0 \\ x(t) = \varphi(t), \quad t_0 - \tau_N \leq t \leq t_0 \\ x'(t_0) = y_0 \end{cases} \tag{2}$$

where $0 \leq \tau_1 \leq \tau_2 < \ldots < \tau_N$, each $a_i : [t_0, +\infty) \to \mathbb{R}$ is piecewise continuous and bounded, f is continuous and bounded, $r : [t_0 - \tau_N, \infty) \to \mathbb{R}$ is piecewise continuous and such that $|\, r(t)\,| \leq R$, $R \geq 1$, and each $b_i : [0, \tau] \to \mathbb{R}$ is Lebesgue integrable with

$$\int_0^{\tau_i} |\, b_i(s)|\, ds \leq B, \quad i = 1, \ldots, N.$$

On the mathematical theory of viscous, compressible, and heat conducting fluids

by *Eduard Feireisl*

We shall discuss some of the recent results concerning the complete system of the Navier–Stokes-Fourier equations describing the time evolution of a compressible, viscous, and heat conducting fluid. We focus on the problems of existence of global-in-time variational solutions for large initial data, and the long-time behaviour of these solutions.

Higher order methods for the numerical solution of the compressible Euler equations

by *Miloslav Feistauer*

The paper is concerned with the numerical simulation of compressible flow with wide range of Mach numbers. We present a new technique which combines the discontinuous Galerkin space discretization, a semi-implicit time discretization and a special treatment of boundary conditions in inviscid convective terms. It is applicable to the solution of steady and unsteady compressible flow with high Mach numbers as well as low Mach number flow at incompressible limit without any modification of the Euler equations. It appears that the method is practically unconditionally stable and robust with respect to the magnitude of the Mach number.

Dimensions of attractors of iterated multifunction systems

by *Jiří Fišer*

At first, we shall briefly recall our results concerning the existence of multivalued fractals. These fractals are defined as attractors of iterated multifunction systems. Then we shall concentrate on the structure of these attractors in terms of fractal dimensions.

Finite time singularities in transport equations with nonlocal velocities and fluxes

by *Marco A. Fontelos*

Navier–Stokes and Euler equations, when written in terms of vorticity, contain nonlinear convective terms which can be written in terms of singular integral (nonlocal) operators of the vorticity itself. This fact suggests the analysis of the role played by nonlocal velocities and fluxes in the formation of singularities. We deduce two one-dimensional analogs of Euler equations, namely:

$$\begin{aligned} 1) \quad \theta_t + (\theta H\theta)_x &= 0, \\ 2) \quad \theta_t - (H\theta)\theta_x &= 0, \end{aligned}$$

with $H\theta$ being the Hilbert transform of θ, and their viscous versions obtained by adding a dissipative term at the right hand side of the equations. We prove that the inviscid equations do develop singularities in finite time while the solutions of the viscous versions do exist for all time. We also discuss connections of these problems with finite time singularities in Birkhoff-Rott equation. Joint work with D. Chae, A. Córdoba and D. Córdoba.

Modeling of liquid flow in vaneless motors

by *Jan Franců*

Vaneless motors are used in practice for their simplicity. The model of liquid flow in these motors consists of the Navier–Stokes equations with a special boundary condition of friction type. The contribution deals with solvability of the boundary value and initial boundary value problems.

High-resolution finite volume methods for advection equations on general grids

by *Peter Frolkovič*

In this talk, we extend the concept of high-resolution Finite Volume Methods (FVM), described by Leveque in his book ”Finite Volume Methods for Hyperbolic Problems”, for general computational grids. These methods use second order accurate approximation for almost all grid points with limiting procedure applied to remaining grid points with, for instance, local extrema of numerical solution. The limiter is optimal in the sense that it reduces the second order approximation in minimal way to obtain discrete maximum principle for numerical solution. The CFL restriction on time steps is removed by using a simple recursive procedure to extend the local character of discretization scheme by including more grid points to the scheme. Application of high-resolution FVM for coupled system of transport equations with different effective velocities and for nonlinear level set equations will be given.

Finite volume schemes for nonlinear convection-diffusion problems based on local Dirichlet problems

by *Jürgen Fuhrmann (joint work with R. Eymard and K. Gärtner)*

Regard the equation $\partial_t u - \Delta\varphi(u) + \nabla\cdot(\vec{q}(x)f(u)) = 0$ in a polygonal domain $\Omega \subset \mathbf{R}^N$ with $N = 1, 2, 3$ with appropriate initial and boundary conditions, div $\vec{q} = 0$, φ strictly monotone and Lipschitz continuous, f continuous.

The idea is to derive the flux function for a finite volume scheme from the solution of local, one-dimensional problems $-\varphi(w)'' + q_{KL}(f(w))' = 0$ with Dirichlet boundary conditions $w(0) = u_K$, $w(h_{KL}) = u_L$, where q_{KL} is the average flux of $\vec{q}$ through a transfer cross section between two adjacent control volumes around discretization nodes x_K,x_L, h_{KL} is the distance between these nodes, and u_K, u_L are the averages of u in these control volumes.

The numerical flux is defined by the constant value $g(u_K, u_L, q_{KL}, h_{KL}) = -\varphi(w)' + q_{KL}(f(w))$.

For the local Dirichlet problem, the existence of a solution and typical properties of numerical fluxes for finite volume schemes have been proven. For the finite volume scheme, stability, existence, uniqueness of the discrete solution and the convergence to a weak solution of the original problem have been shown.

Ways to calculate the flux functions for particular problems will be discussed. Numerical examples will illustrate the advantages of the method.

Convergence to equilibrium in two-dimensional viscous flows

by *Thierry Gallay*

We consider the Navier–Stokes equation for an incompressible viscous fluid filling the whole plane R^2. Using an entropy functional, we show that any solution whose vorticity distribution is integrable converges as time goes to infinity to an explicit self-similar solution called ”Oseen's vortex”. This global convergence result is intimately related to the uniqueness problem for the solution of the vorticity equation with measure-valued initial data, a question that we also answer positively.

Existence and stability of asymmetric Burgers vortices

by *Thierry Gallay*

Burgers vortices are stationary solutions of the three-dimensional Navier–Stokes equations in the presence of a background straining flow. These solutions are given by explicit formulas only when the strain is axisymmetric. In this talk we first consider a weakly asymmetric strain and prove in that case that non-axisymmetric vortices exist for all values of the Reynolds number, and are stable with respect to spatially localized two-dimensional perturbations. We next prove that this family of stationary solutions is also asymptotically stable with shift when three-dimensional perturbations are considered, provided the Reynolds number is sufficiently small.

Numerical methods for hyperbolic systems with discontinuous coefficients or sources terms

by *Thierry Gallouët*

Recent papers were devoted to the study of two related problems: hyperbolic systems with discontinuous coefficients and hyperbolic systems with sources terms. I will present in this talk some possible numerical methods in order to obtain approximate solutions of such problems.

Optimization and the Miranda theorem in detecting horseshoe-type chaos by computer

by *Barnabas M. Garay*

This is a contribution to computer-assisted proofs for chaos in discrete-time and continuous-time dynamical systems. What the computer does is the verified checking of a finite number of certain subset relations associated with the dynamics. The collection of these subset relations forms a sufficient condition for chaos in a region determined by the subset relations themselves. The underlying abstract theorems are simplified by the following observation. In most of the by now classical applications, degree and/or Conley index arguments can be replaced by the more elementary Miranda theorem. In order to locate chaotic regions, one has to find the subset relations to be checked. Since the possible subset relations depend on parameters, this is the terrain of optimization methods. The search for chaotic regions can be modelled as a constraint satisfaction problem. The constraints are represented by a penalty function approach and global optimization techniques apply. Results for the Henon mapping and for a forced damped pendulum equation are presented.

This is joint work with Balazs Banhelyi, Tibor Csendes, and Laszlo Hatvani.

Phase field models for surface diffusion

by *Harald Garcke*

We present a phase field model for surface diffusion taking into account electromigration, elastic effects and grain boundary motion. We describe some analytical results relevant for the modelling and present a fully practical finite element approximation for the phase field model. Finally, applications to quantum dot formation in heteroepitaxial strained films and intergranular void evolution in microelectronic devices are discussed.

Patterns in multicomponent alloy solidification

by *Harald Garcke*

We present a diffuse interface model for phase transformations in multicomponent alloys. First we discuss how it is possible to approximate sharp interface models to second order. Then we describe how surface effects in multi-phase systems can be incorporated in a phase field model and finally we discuss several patterns occuring in such systems and in particular situations with triple junctions are presented.

Strong L^p-solutions of Navier–Stokes equations in the exterior of a rotating obstacle

by *Matthias Geissert*

We consider Navier–Stokes equations in the exterior of a rotating obstacle. After a suitable change of coordinates we obtain non-autonomous equations. The solutions of the linearized, non-autonomous equations satisfy a maximal L^p regularity estimate. This leads to a unique local strong solution to the original problem.

Asymptotic behavior of bi-coupled slow-fast systems

by *Katrin Gelfert*

The asymptotic behavior of solutions of ordinary differential equations which combine slow and fast motions is investigated. The averaging principle suggests that solutions of an averaged equation provide a good approximation for the slow motion. However, in the case that the slow and the fast motions are bi-coupled, this principle can not always be applied. We give sufficient conditions under which the averaging principle for bi-coupled systems justifies almost everywhere and not only in some averaged (with respect to any initial conditions) sense. We consider the case that the fast motion is governed by hyperbolic flows in the neighborhood of an attractor.

The Navier–Stokes flow with almost periodic initial data

by *Yoshikazu Giga*

This is a joint work with A. Mahalov and B. Nicolaenko of Arizona State University. When we consider the Navier–Stokes flow with a peridic initial data, it is well-known that the periodicity is preserved under the flow. A natural equation is whether the almost periodicity preserved under the flow. Such a question is not obvious for the Navier–Stokes flow since the initial data does not decay at the space infinity. Nevertheless we give an affirmative answer not only to the Navier–Stokes flow but also to the Navier–Stokes flow with the Coriolis force.

An application of crystalline curvature to describe bunching phenomena

by *Yoshikazu Giga*

This is partly based on my joint work with Mi-Ho Giga (University of Tokyo) and Y-H. R. Tsai (University of Texas). We consider a class of the first order equation whose solution develops jump discontinuities. It includes equations describing bunching phenomena as well as the Burgers equation. We develop a level set method to track such a solution by using a special crystalline energy which prevents overturning of solutions.

The Cauchy problem without growth restrictions of the data at infinity

by *Alexander Gladkov*

We consider the Cauchy problem for different kind of nonlinear parabolic equations without growth restrictions on initial data at infinity. The existence and uniqueness of solutions under such general initial data is not common case in parabolic problems. For example, to get the existence and uniqueness of solution of the Cauchy problem for any linear parabolic equation we should restrict the growth of initial function and solution at infinity. We are going to consider in a talk diffusion-absorption equation with nonlinearities of general type, parabolic equation with gradient nonlinearity, porous medium equation with absorption and a variable coefficient, semilinear higher-order parabolic equation and parabolic equation with double nonlinearity.

About an appearance of stationary resonance regimes for nonlinear integro-differential equation

by *Alexander Domoshnitsky and Yakov Goltser*

Our goal is to study the parametrically perturbed Volterra Integro-Differential equation (IDE) in R^n

$$x'(t) = X(t, x, \mu, \int_0^t K(\mu, t, s)g(\mu, x(s))ds) \tag{1}$$

with the kernel in the form $K(t, s) = \sum_{l,m=1}^{\infty} C_{lm}(\mu)\phi_l(t)\psi_m(s)$.

A special method reducing system (1) to countable system of Ordinary Differential equation (ODE) developed by the authors in previous papers is used. The suggested reduction method allows introduction for nonlinear IDEs the notion of the first-order approximating system in the form countable linear ODEs, spectrum of this approximation and classification of stability cases into critical and noncritical cases. The main attention is devoted to the bifurcation problem of an appearance of stationary resonance regimes for (1) in the case when this spectrum can cross the imaginary axis while the parameter μ changes. The important example of such systems is the system of nonlinear oscillators with integral nonlinear constraints

$$x''(t) + \omega^2 x(t) = f(\mu, x(t), x'(t)) + \int_0^t K(t, s, \mu)G(\mu, x(s), x'(s))ds,$$

where $x \in R^n, \omega^2$ is a diagonal matrix.

Carathéodory solutions to quasi-linear hyperbolic systems of partial differential equations with state dependent delays

by *Agata Gołaszewska and Jan Turo*

The paper addresses the existence of a generalized solution and continuous dependenceupon initial data for hyperbolic functional differential systems with state dependent delays. The method used in this paper is based on the bicharacteristics theory and on the Banach fixed point theorem. The formulation includes retarded argument, integral and hereditary Volterra terms.

Evolution of crystals in three dimensions

by *Przemysław Górka*

We consider a system modeling evolution of a single crystal grown from vapor. We account for vapor diffusion and Gibbs-Thomson relation on the crystal surface. Mathematically speaking, this is a one-phase Stefan-type problem with the curvature and kinetic terms. It is important to stress that we consider is in unbounded space, i.e. outside of a crystal. We consider a polyhedral initial domain, i.e. our evolving crystal. And in this domain (changing in time) we have the diffusion equation. The main difficulty in the mathematical treatment is changing in time domain of the diffusion equation. We transform the system to fixed domain. The resulting system is nonlinear in a domain with singularities. We show local in time existence of a solutions.

On the stability of periodic orbits for differential systems in $\mathbb{R}^n$

by *Armengol Gasull, Héctor Giacomini and Maite Grau*

We consider a differential system in $\mathbb{R}^n$, $n \geq 2$, given by $\dot{\mathbf{x}} = \mathbf{P}(\mathbf{x})$ where $\mathbf{P} : \mathcal{U} \subseteq \mathbb{R}^n \to \mathbb{R}^n$ is a $\mathcal{C}^1$ function in some open set $\mathcal{U} \subseteq \mathbb{R}^n$ and the dot means the derivative with respect to a variable $t \in \mathbb{R}$. All the functions considered are of class $\mathcal{C}^1$ in $\mathcal{U}$. Let $\Gamma := \{\gamma(t) \,|\, 0 \leq t < T\}$ be a periodic orbit with period $T > 0$ of the system in $\mathcal{U}$.

Assume that $n = 2$ and that the periodic orbit Γ is contained in the zero–set of a curve $f = 0$ such that ∇f is not null in any point of Γ. Then, there exists a function k satisfying that $\mathbf{P} \cdot \nabla f = k\, f$ and the stability of Γ can be determined by the sign of $\int_0^T k(\gamma(t))\, dt$. This statement has been proved in [GG].

Our purpose is to generalize this result for $n > 2$. We consider a function $\mathbf{f} : \mathcal{U} \subseteq \mathbb{R}^n \to \mathbb{R}^{n-1}$ such that the periodic orbit Γ is contained in the intersection of the manifolds $f_i(\mathbf{x}) = 0$ for $i = 1, 2, \ldots, n-1$, where f_i denotes the i^{th}–component of $\mathbf{f}$, and we assume that the crossings of all the manifolds $f_i(\mathbf{x})$ are transversal over Γ. Assume that there exists a $(n-1) \times (n-1)$ matrix of functions $\mathbf{k}$ satisfying $\mathbf{P}(\mathbf{x}) \cdot D\mathbf{f}(\mathbf{x}) = \mathbf{f}(\mathbf{x}) \cdot \mathbf{k}(\mathbf{x})$. Let $\mathbf{v}(T)$ be the monodromy matrix associated to the T–periodic system $(d\mathbf{v}/dt)(t) = \mathbf{k}(\gamma(t)) \cdot \mathbf{v}(t)$. We prove that the eigenvalues of $\mathbf{v}(T)$ determine the stability of Γ in the Liapunov sense.

[GG] H. Giacomini and M. Grau, *On the stability of limit cycles for planar differential systems*, to appear in J. Differential Equations (in press).

Optimal lower bounds on waiting times for degenerate parabolic equations and systems

by *Günther Grün*

We present a new analytical tool to prove lower bounds on waiting time for free boundary problems associated with degenerate parabolic equations and systems. Our approach is multi-dimensional, it applies to a large class of equations, including thin-film equations, (doubly) degenerate equations of second and of higher order and also systems of semiconductor equations.

In terms of scaling, our result is optimal for the porous-medium equation. This is the only equation for which waiting time bounds have been established so far (see Aronson, Caffarelli, Kamin (SIMA 14 (1983), pp. 639–658) for results in 1D, Chipot, Sideris (Trans. AMS 288 (1985), pp. 423–435) for upper bounds in multi-D). Based on new finite-element schemes for doubly-degenerate thin-film equations, we give numerical evidence that our bounds provide the right scaling for these equations, too. (joint work, partially with L. Giacomelli, partially with J. Becker)

On similarity and pseudo-similarity solutions of Falkner–Skan problems

by *Zakia Hammouch*

This paper deals with the two-dimensional incompressible, laminar, steady-state boundary layer equations. We determine a family of the velocity distribution outside the boundary layer such that these problems have similarity solutions. We examine in detail new exact solutions, called pseudo-similarity, where the external velocity is given by $U_e(x) = U_\infty x^{-1}$. The analysis shows that solutions exist only for a lateral suction. Here it is assumed that the flow is induced by a continuous permeable surface with the stretching velocity $U_w x^{-1}$. For specified conditions, we establish the existence of an infinite number of solutions, including monotone solutions and solutions which oscillate an infinite number of times and tend to a limit. The properties of solutions depend on the suction parameter.

Analysis tools for finite volume methods in PDE's

by *Raphaèle Herbin*

The finite volume method is a discretization method which is well suited for the numerical simulation of various types (elliptic, parabolic or hyperbolic, for instance) of conservation laws; it is extensively used in several engineering fields, such as fluid mechanics, heat and mass transfer, semi-conductor technologies or petroleum engineering. Some of the important features of the finite volume method are similar to those of the finite element method: it may be used on arbitrary geometries, using structured or unstructured meshes, and it leads to robust schemes. It is often used in industrial codes because of its ease of implementation, especially so in the case of coupled equations of different types (hyperbolic, parabolic, algebraic...)

The analysis of the cell centered finite volume methods for elliptic and parabolic problems is more recent than that of the finite element, in particular because of its nonconforming feature, in the sense that the (piecewise constant) approximate solutions do not belong to a space included in that of the continuous solutions. Because of this lack of regularity, the convergence analysis of the scheme requires some discrete functional analysis tools which mimic the usual continuous compactness arguments. In this talk, we shall try to establish some parallels between this discrete (finite volume) framework and the continuous PDE setting.

The Navier–Stokes flow in the exterior of a rotating obstacle

by *Matthias Hieber*

In this talk we consider the equations of Navier–Stokes in the exterior of a rotating domain. It is shown that, after rewriting the problem on a fixed domain Ω, the solution of the corresponding Stokes equation is governed by a semigroup on $L^p(\Omega)$ for $1 < p < \infty$. This implies the existence of local solutions to the Navier–Stokes equations.

A combined finite volume–nonconforming finite element scheme for a degenerate parabolic equation

by *Robert Eymard, Danielle Hilhorst and Martin Vohralík*

Degenerate parabolic convection–reaction–diffusion equations arise in many contexts, such as porous medium flow, fluid dynamics, or heat conduction. We study here an equation modelling contaminant transport in porous medium with equilibrium adsorption reaction in space dimension two or three. It has the form

$$\beta(c)_t - \text{ div } (\mathbf{S} \text{ grad } c) + \lambda \text{ div } (c\, \mathbf{v}) + F(c) = q,$$

where c is the unknown concentration of the contaminant, the function $\beta(c)$, which represents time evolution and equilibrium adsorption reaction, is continuous and strictly increasing, $\mathbf{S}$ is a possibly heterogeneous and anisotropic diffusion–dispersion tensor, $\mathbf{v}$ is the velocity field in the convection term, the function $F(c)$ represents the changes due to chemical reactions, q stands for the sources, and λ is a scalar parameter.

We discretize the diffusion term by means of piecewise linear nonconforming finite elements over a triangulation of the space domain. The other terms are discretized by means of a finite volume scheme on a dual mesh. Checking the local Péclet number, we set up the exact necessary amount of upstream weighting to avoid spurious oscillations in the velocity dominated case. This technique ensures the validity of the discrete maximum principle under some extra conditions on the triangulation and the diffusion tensor. We prove the convergence of the numerical scheme and present numerical tests.

Finally we show how one can extend such a method to the case of nonmatching grids. This permits in particular to locally refine a rectangular grid in the neighborhood of contaminated zones, which is quite important from the application viewpoint.

Peak solutions in an elliptic chemotaxis-like system

by *E. N. Dancer and D. Hilhorst*

Convergence to peak solutions in elliptic reaction-diffusion systems has been very much studied in recent years. We will consider a chemotaxis-like system and analyze the influence of the convection term in a first simple case.

This study is inspired upon a formal computation performed by D. Hilhorst, H. Matano and M. Mimura.

Multiple existence of solutions for semilinear elliptic problems

by *Norimichi Hirano*

Let $N \geq 3$ and $p \in (2, 2^*]$, where $2^* = 2N/(N-2)$. In this talk, we consider the existence of solutions of problem

$$\begin{cases} -\Delta u + u & = & |u|^{p-1} u + f & \quad \text{on} \quad & \mathbb{R}^N \\ u & \in & H^1(\mathbb{R}^N) & & \end{cases}$$

where $H^1(\mathbb{R}^N) = \{v \in L^2(\mathbb{R}^N) : |\nabla v| \in L^2(\mathbb{R}^N)\}$ and $f \in L^{p/(p-1)}(\mathbb{R}^N) \cap L^\infty(\mathbb{R}^N)$ with $f \geq 0$ and $f \not\equiv 0$. We give the existence and multiplicity results for this problem.

Stationary Navier–Stokes flows around a rotating obstacle

by *Toshiaki Hishida*

Consider a viscous incompressible fluid filling the whole 3-dimensional space exterior to a rotating body with constant angular velocity ω. By using the coordinate system attached to the body, the problem is reduced to an equivalent one in the fixed exterior domain. The reduced equation then involves the important drift operator $(\omega \wedge x) \cdot \nabla$, which is not subordinate to the usual Stokes operator and causes some difficulties. This talk addresses stationary flows to the reduced problem with the external force $f = \text{div}\, F$, that is, time-periodic flows to the original one. We show the existence of a unique solution in the class $(\nabla u, p) \in L_{3/2,\infty}$ when both $F \in L_{3/2,\infty}$ and ω are small enough, where $L_{3/2,\infty}$ is the weak-$L_{3/2}$ space. This result provides another outlook on the previous work of G. P. Galdi, who has derived some remarkable pointwise estimates of solutions. In fact, our class of solutions is consistent with his estimates, and our class of external forces is larger than his.

This talk is based on a joint work with Reinhard Farwig (TU Darmstadt, Germany).

Special Bihari type integral inequalities

by *László Horváth*

Let $(X, \mathcal{A}, \mu)$ be a measure space. We consider integral inequalities

$$y(x) \leq f(x) + g(x) \int\limits_{S(x)} y^{\alpha} d\mu, \quad x \in X \tag{1}$$

with $0 < \alpha < 1$. The formal assumptions on the functions $y,\ f,\ g : X \to \mathbb{R}$ and $S : X \to \mathcal{A}$ are listed in the main theorems.

We give explicit upper bounds for the solutions of (1) under very weak hypotheses on the function S. We assume only that it satisfies the condition

(C2) if $y \in S(x)$, then $S(y) \subset S(x)$, $x \in X$.

If the additional condition

(C3) $\{(x_1, x_2) \in X^2 \mid x_2 \in S(x_1)\}$ is $\mu \times \mu$-measurable

is also supposed, then it is possible to show deeper properties of the bounds for the solutions of (1).

Finally we illustrate the scope of the results by applying them to establish the existence of a solution to the integral equations corresponding to (1).

A modified spectral method for ODEs with non-analytic or impulse solution

by *M. M. Hosseini*

Here there is an attempt to introduced, generally, spectral methods for numerical solution of ordinary differential equations (ODEs), also, to focus on those problems in which some coefficient functions or solution function is not analytic. In addition, the ODEs with impulse solution is considered. Then by expressing weak and strong aspects of spectral methods to solve these kinds of problems, a modified spectral method which is more efficient than other spectral methods is suggested. Furthermore, with providing some examples, the aforementioned cases are dealt with numerically. For more detail refer to [1,2,3].

[1] A modified spectral method for numerical solution of ordinary differential equations with non-analytic solution, Applied Mathematics and Computation, 132(2002) 341-351.

[2] Numerical solution of ordinary differential equations with impulse solution, Applied Mathematics and Computations, 163(2005) 373-381.

[3] Pseudospectral Method for Stiff Ordinary Differential Equations with An Error Estimation, Applied Mathematics and Computations, Submitted.

On a thermomechanical model of surface heat treatments

by *Dietmar Hömberg*

I will discuss a macroscopic thermomechanical model of phase transitions in steel. Effects like transformation strain and transformation plasticity induced by the phase transitions will be considered and used to formulate a consistent thermomechanical model. The physical parameters are allowed to depend on the respective phase volume fractions by a mixture ansatz.

The resulting system of state equations consists of a quasistatic momentum balance coupled with a nonlinear stress-strain relation, a nonlinear energy balance equation and a system of ODEs for the phase volume fractions. I will prove the existence of a weak solution and show some results of numerical simulations.

Free boundary problems in combustion

by *Josephus Hulshof*

Combustion in gaseous mixtures is often modelled by diffusion equations for temperature and fuel mass fraction, with jump conditions for heat and mass fluxes at the free boundary. I will discuss stability aspects of travelling waves and radially symmetric stationary and selfsimilar solutions of such models.

Harnack inequality and exponential separation for oblique derivative problems on Lipschitz domains

by *Juraj Húska*

We consider the oblique derivative problem for linear nonautonomous second order parabolic equations with bounded measurable coefficients on bounded Lipschitz cylinders. We derive an optimal elliptic-type Harnack inequality for positive solutions of this problem and use it to show that each positive solution exponentially dominates any solution which changes sing for all times. We show several nontrivial applications of both the exponential estimate and the derived Harnack inequality.

The small obstacle limit in a viscous incompressible flow

by *Dragoş Iftimie*

We consider a bidimensional incompressible viscous flow in the exterior of an obstacle that shrinks to a point. Under the hypothesis that 1) the initial vorticity and velocity's circulation on the boundary of the obstacle are independent of the obstacle and 2) the velocity's circulation is small independently of the size of the obstacle, we determine the limit velocity. This result extends a previous paper by the same authors which deals with the same problem in the inviscid case. This is work in collaboration with M. Lopes and H. Nussenzveig Lopes.

Energy expansion and vortex location for a two dimensional rotating Bose-Einstein condensate

by *Radu Ignat*

We investigate the physical model for a two dimensional rotating Bose-Einstein condensate. We minimize a Gross-Pitaevskii functional defined in $\mathbb{R}^2$ under the unit mass constraint. We estimate the critical rotational speeds Ω_d for having d vortices in the bulk of the condensate and we determine the location of the vortices. This relies on an asymptotic expansion of the energy.

Strict φ-disconjugacy of n-th order linear differential equations with delays

by *František Jaroš*

The aim of this paper is a generalization of the strict disconjugacy for a linear differential equations with delay. We consider the n-th order linear differential equations with delays

$$x^{(n)}(t) + \sum_{i=1}^{n} \sum_{j=1}^{m} a_{ij}(t) x^{(n-i)}\big(t - \varDelta_{ij}(t)\big) = 0 \ , \quad n \geq 1 \ ,$$

with continuous coefficients $a_{ij}(t)$ and delays $\varDelta_{ij}(t) \geqslant 0$ on an interval $\mathbf{I} = \langle t_0, T), T \leqslant +\infty \quad (i = 1, \cdots, n; \ j = 1, \cdots, m)$. It is shown that for each fixed continuous and bounded initial vector function φ interval of φ-disconjugacy of each differential equation does not degenerate into a one-point set. The relation between strict φ-disconjugacy and the existence of solutions of multipoint boundary value problems is discussed.

Robin type conditions arising from concentrated potentials

by *José M. Arrieta and Ángela Jiménez-Casas*

We analyze the limit of solutions of an elliptic problem, with zero flux boundary conditions when the potential functions are concentrated in a neighbourhood of the boundary and this neighborhood shrinks to the boundary as a parameter goes to zero.

We prove that this family of solutions converges, in the sup norm, to the solutions of an elliptic problem with Robin type condition.

This Robin type conditions for the limiting problem comes from the concentrated potentials around the boundary of the domain.

Interior regularity for weak solutions of nonlinear second order elliptic and parabolic systems

by *Josef Daněček, Oldřich John and Jana Stará*

The interior $C^{0,\gamma}$-regularity for the first gradient of weak solutions to a class of nonlinear second order elliptic and parabolic systems is proved. In the elliptic case the systems are of the type

$$D_\alpha(A_i^\alpha(Du)) = 0, \quad i = 1, ..., N, \quad \alpha = 1, ..., n.$$

The regularity result is proved under the assumption that the derivative of the modulus of continuity of $\partial A_i^\alpha / \partial p_j^\beta$ is small enough with respect to the ellipticity constant ν.

Solution of inverse problems in contaminant transport with adsorption

by *Jozef Kačur and Jela Babušíková*

Solution of inverse problems in contaminant transport is studied including nonlinear adsorption in equilibrium and nonequilibrium mode. The precise numerical solver for the direct problem is discussed. The method is based on time stepping and operator splitting with respect to the nonlinear transport, diffusion and adsorption. Nonlinear transport is based on the solution of Rieman problems and modified front tracking method. The inverse problem is based on the iteration process using the gradient of the corresponding cost functional with respect to the parameters underlying for the determination. The gradient is constructed via the solution of the corresponding adjoint system. Numerical experiments are presented for the daual-well environment with the steady state flow between the injection and extraction wells.

Symmetric mountain pass lemma and multiple solutions of sublinear elliptic equations

by *Ryuji Kajikiya*

I present an additional theorem to the symmetric mountain pass lemma and apply it to sublinear elliptic equations. Let E be an infinite dimensional Banach space and let Γ_k denote the family of closed symmetric subsets A of E such that $0 \notin A$ and $\gamma(A) \geq k$. Here $\gamma(A)$ denotes the genus of A.

Assumption (A). Let I be a C^1 functional on E.

(A1) $I(u)$ is even, bounded from below, $I(0) = 0$ and $I(u)$ satisfies the Palais-Smale condition.

(A2) For each integer k, there exists an $A_k \in \Gamma_k$ such that $\sup_{u \in A_k} I(u) < 0$.

Theorem 1. Under Assumption (A), either (i) or (ii) below holds.

(i) There exists a sequence $\{u_k\}$ such that $I'(u_k) = 0$, $I(u_k) < 0$ and $\{u_k\}$ converges to zero.

(ii) There exist two sequences $\{u_k\}$ and $\{v_k\}$ such that $I'(u_k) = 0$, $I(u_k) = 0$, $u_k \neq 0$, $\lim_{k\to\infty} u_k = 0$, $I'(v_k) = 0$, $I(v_k) < 0$, $\lim_{k\to\infty} I(v_k) = 0$, and $\{v_k\}$ converges to a non-zero limit.

Asymptotic properties of a two-dimensional differential system with delay

by *Josef Kalas*

We present some results on the asymptotic behaviour of the solutions of a real two-dimensional system $x' = \mathsf{A}(t)x(t) + \mathsf{B}(t)x(t-r) + h(t, x(t), x(t-r))$, where $r > 0$ is a constant delay, under the assumption of instability. Here A, B and h denote matrix functions and a vector function, respectively. The conditions for the existence of bounded solutions or solutions tending to the origin as $t \to \infty$ are given. The method of investigation is based on the transformation of the considered real system to one equation with complex-valued coefficients. Asymptotic properties of this equation are studied by means of a suitable Lyapunov-Krasovskii functional and by virtue of the Ważewski topological principle. The results supplement those of [1], where the stability and asymptotic behaviour were investigated for the stable case.

[1] J. Kalas, L. Baráková, *Stability and asymptotic behaviour of a two-dimensional differential system with delay*, J. Math. Anal. Appl. 269, (2002), no. 1, 278–300.

Smooth and singular solutions to the incompressible Navier–Stokes system

by *Grzegorz Karch*

The goal of the talk is to present some recent results on the existence of singular solutions of the incompressible Navier–Stokes system with singular external forces as well as the existence of regular solutions for more regular forces, in the case of small initial data. Moreover, it will be explained how to use the Marcinkiewicz space $L^{3,\infty}$ and other spaces of tempered distributions to show asymptotic stability results for solutions with infinite energy. This approach will be applied in the analysis of two classical "regularized" Navier–Stokes system. The first one was introduced by J. Leray and consists in "mollifying" the nonlinearity. The second one was proposed by J.-L. Lions who added the artificial hyper-viscosity $(-\Delta)^{\ell/2}$, $\ell > 2$, to the model. We prove that solutions to those modified models converge as $t \to \infty$ toward solutions of the original Navier–Stokes system.

M. Cannone and G. Karch, *Smooth or singular solutions to the Navier–Stokes system?*, J. Diff. Eq. **197** (2004), 247–274.

M. Cannone and G. Karch, *About the regularized Navier–Stokes equations*, J. Math. Fluid Mech. **7** (2005), 1–28.

Attractivity results for nonlinearly damped second order oscillator equations

by *János Karsai and John R. Graef*

We investigate the asymptotic behavior of the system

$$x'' + a(t)|x'|^{\beta}\text{sign}(x') + f(x) = 0 \quad (t \geq 0, \;\; a(t) \geq 0),$$

where $\beta > 0, xf(x) > 0,\ x \neq 0$. The properties of this system with linear terms $\beta = 1,\ f(x) = x$ is well known. The importance of the nonlinearity of $f(x)$ is especially characteristic in the case of small damping and it is studied by several authors. There are also results proved for systems containing nonlinear damping terms, but, for example, the case of sublinear damping is hardly investigated as yet, although its behavior is essentially different from the linear and superlinear cases.

In the talk, we present new results for the asymptotic behavior of the solutions, at different kind of nonlinearities (for example, sub- and superlinear type) in the damping term. We show computer experiments to demonstrate the differences in the stucture of the set of solutions. We also consider equations with more general nonlinearities.

A finite element approximation of the Bean critical state model for superconductivity

by *Yohei Kashima*

A finite element analysis of the Bean critical state model for superconductivity, which is a macroscopic model of type II superconductivity, is considered. We formulate the electoromagnetic field around the high temperature bulk superconductor located in 3D configuration in an evolution variational inequality. The discretization is carried out by employing curl conforming edge element. The convergence to the analytical solution will be argued. Some numerical results will be reported.

Overdetermined problems and the p-Laplacian

by *Bernd Kawohl*

In this talk I report on two results. The first one is joint work with I. Fragalá and F. Gazzola on overdetermined problems like $-\Delta_p u = 1$ in Ω, $u = 0$ *and* $\partial u/\partial\nu = -a$ on $\partial\Omega$. I present a somewhat more geometric proof than the ones of Serrin and Weinberger, and it covers more general (degenerate) equations. The second result is joint work with H. Shahgholian about Bernoulli-type free boundary problems. Given a bounded domain Ω_1 the minimizers u_p of $E_p(u) = \int_{\mathbb{R}^n} |\nabla u|^p + (p-1)\chi_{u>0}\,dx$ on $\{u \in W^{1,p}(\mathbb{R}^n);\ u \equiv 1 \text{ on } \Omega_1\}$ are p-harmonic in their support (minus Ω_1) and satisfy $u = 0$ and $\partial u/\partial\nu = -1$ on the (free) boundary of their support. I investigate this problem as $p \to \infty$ and $p \to 1$.

Implicit difference methods for first order partial differential functional quasilinear equations

by *Anna Kepczynska*

We present a new class of numerical methods for quasilinear first order partial functional differential equations. The numerical methods are difference schemes which are implicit with respect to time variable. We proved a theorem on the error estimates of approximate solutions for difference functional equations. We applied this idea to the investigation of the convergence of implicit schemes. The proof of the stability is based also on a comparison technique with nonlinear estimates of the Perron type for given operators with respect to the functional variable.

It is important in our considerations that in convergence theorems for implicit difference methods we can omit the following assumption

$$1 - h_0 \sum_{i=1}^{n} \frac{1}{h_i} |f_i(t, x, w)| \geq 0$$

which is assumed in classical theorems concerning difference methods for quasilinear functional differential problems.

We show by an example that the new methods are considerable better then the explicit schemes.

Instantaneous extinction, step discontinuity and blow-up phenomena in reaction-diffusion theory

by *Robert Kersner*

This talk concerns reaction-diffusion processes described by the PDE

$$u_t = (D(u)u_x)_x - F(u)$$

and the corresponding ($u = f(x - ct)$) ODE

$$(D(f)f')' + cf' - F(f) = 0.$$

The role of variable

$$Q(s) = (2\int_0^s D(r)F(r)dr)^{1/2}$$

is discussed. For $Q = \infty$ (example: $D = 1$, $F = 1/u$) we formulate some results, give the idea of proofs and mention some consequences.

DUNE - Distributed and Unified Numerics Environment

by *Robert Klöfkorn*

Most finite element software is built around a fixed mesh data structure. Therefore, each software package can only be used efficiently for a relatively narrow type of applications. In this talk the speaker will show how a generic mesh interface can be defined such that one algorithm or discretization scheme works on different mesh implementations. The grid interface of DUNE (see [1]) is discussed and some aspects of modern concepts for efficient numerical calculation such as local adaptivity and parallelisation including load balancing implemented upon the grid interface is presented.

[1] P. Bastian, M. Droske, C. Engwer, R. Klöfkorn, T. Neubauer, M. Ohlberger, M. Rumpf. Towards a Unified Framework for Scientific Computing. *In Proceedings of the 15th International Conference on Domain Decomposition Methods*, 2004.

[2] Homepage of DUNE: `http://dune.uni-hd.de`

Stability of vortex solutions to nonlinear Schrödinger equations

by *Richard Kollar*

The structure of the nonlinear Schrödinger equation supports existence of topologically non-trivial solutions – vortices. Their stability is studied by the means of a very robust method – the Evans function. Besides studying a particular case of NLS we discuss some general (analytical and numerical) simplifications for the traditional method.

An example of discontinuous solution for a quasilinear hyperbolic equation with hysteresis

by *Petra Kordulová*

A quasilinear hyperbolic equation with hysteresis is studied. For the classical play operator we obtain a continuous solution. For a special example of the hysteresis operator we show that the equation must exhibit discontinuity.

On a nonlinear evolution equation

by *Dimitrios Kravvaritis*

We consider a nonlinear evolution equation, defined on an evolution triple of spaces and containing operators of monotone type.

Using a surjectivity theorem about two operators of monotone type we prove the existence of solution of our evolution problem.

Fefferman's inequality and related topics

by *Miroslav Krbec*

We shall discuss the uncertainty principle in the form of the model inequality

$$\int_\Omega u^2(x)V(x)\,dx \le c\int_\Omega |\nabla u(x)|^2\,dx, \quad u \in W_0^{1,2}(\Omega),$$

and survey various sufficient conditions for V and techniques based on critical imbeddings of Sobolev spaces and on the Littlewood–Paley weighted decompositions.

Nonresonance and energy decay of oscillations in hysteretic media

by *Pavel Krejčí*

We consider a model for wave propagation in elastoplastic materials in the form of the first order system

$$\begin{aligned} \partial_t v &= \partial_x \sigma + f(\sigma, v, x, t)\,, \\ \partial_t \varepsilon &= \partial_x v\,, \\ \varepsilon &= F[\sigma] \end{aligned}$$

for $(x,t) \in (0,1) \times (0,\infty)$, where v, ε, and σ represent the velocity, strain, and stress, respectively, F is a counterclockwise convex hysteresis operator, and f is a given Lipschitz continuous function. Unlike in viscoelasticity, the speed of propagation is bounded above by the speed of the corresponding elastic waves. On the other hand, due to the convexity of the hysteresis branches, shocks do not occur. Using the gas dynamics terminology, we may say that only rarefaction takes place. The aim of this contribution is to present some new results on the long time behaviour of solutions under various boundary conditions, including the stability of time-periodic solutions if f is periodic in t, even if hysteresis is the only source of energy dissipation.

Smooth invariant manifolds for state dependent FDEs

by *Tibor Krisztin*

In this talk the problem of existence of smooth local invariant manifolds for state dependent delay differential equations is considered near stationary points. The lack of sufficient smoothness of the solution operator is the main reason why classical techniques do not seem to be applicable. We present some new results open problems.

Implicit difference methods for parabolic functional differential equations

by *Karolina Kropielnicka*

We present a new class of numerical methods for parabolic functional differential equations with initial boundary conditions of the Dirichlet type. Classical solutions of equations

$$\partial_t z(t,x) = f(t,x,z_{(t,x)},\partial_x z(t,x),\partial_{xx} z(t,x))$$

are approximated by solutions of implicit (with respect to the time variable) difference schemes

$$\delta_0 z^{(r,m)} = f_h(t^{(r)},x^{(m)},z_{[r,m]},\delta z^{(r+1,m)},\delta^{(2)} z^{(r+1,m)}).$$

We prove that under natural assumptions on f_h there exists exactly one solution of the problem consisting of the above difference functional equation and a suitable initial boundary condition.

We give a complete convergence analysis for the methods and we show by examples that the new methods are considerable better than the explicit schemes.

Differential equations with deviated variables and differential integral problems can be obtained as particular cases from a general model by specializing given operators.

Asymptotic equivalence of systems of difference equations

by *Jaromír Kuben*

The system of difference equations

$$\Delta x_n = Ax_n + f(n,x_n), \tag{1}$$

where A is a $k \times k$ matrix, $k \in \mathbb{N}$, $x_n \in \mathbb{R}^k$, $n \in \mathbb{N}_0$ and $f\colon \mathbb{N}_0 \times \mathbb{R}^k \to \mathbb{R}^k$, and the corresponding linear system

$$\Delta y_n = Ay_n \tag{2}$$

are considered.

The systems (1) and (2) are said to be *asymptotically equivalent* if to each solution x_n, $n \in \mathbb{N}(a)$, of (1) there is a solution y_n, $n \in \mathbb{N}(b)$, of (2) such that

$$\lim_{n\to\infty} |x_n - y_n| = 0 \tag{3}$$

and conversely to each solution y_n, $n \in \mathbb{N}(a)$, of (2) there exists a solution x_n, $n \in \mathbb{N}(b)$, of (1) such that (3) holds. More generally only the equivalence between some subsets of solutions can be investigated.

In the contribution sufficient conditions are given for the equivalence between bounded solutions of systems (1) and (2).

Complex dynamics of CO oxidation in catalytic converter

by *Matyáš Schejbal, Igor Schreiber and Milan Kubíček*

A mathematical model of heterogeneous catalytic converter for CO oxidation has been developed. CO oxidation is an important reaction taking place in catalytic converters of automobile exhaust gases. Our model includes mass balances in the bulk gas, mass transfer to the catalyst and CO oxidation on the catalyst surface, described by 8 reaction steps. Mass balances of the components deposited on the catalyst surface and enthalpy balances are also included. The resulting stiff system of ODEs has been solved by implicit integration method. Nonlinear dynamics of the converter has been observed in the simulations, including coexistence of stable oscillations and stable steady states. Continuation methods and bifurcation analysis have been employed in the parametric study of the system with the software package CONT. Complex dynamics of the system for periodic variation of inlet parameters will be discussed.

On asymptotic properties of linear delay differential equation with a forcing term

by *Petr Kundrát*

The contribution deals with the asymptotic behaviour of solutions of delay differential equation with a forcing term

$$\dot{x}(t) = a(t)x(t) + b(t)x(\tau(t)) + f(t), \quad t \in [t_0, \infty),$$

where $a > 0, b$ are functions such that $|b|/a$ is estimated by continuous and nonincreasing function. Some particular cases of the studied equation are discussed as well.

Some existence result to elliptic equations with semilinear coefficients

by *Tsang-Hai Kuo*

For the quasilinear elliptic equation

$$-\sum_{i,j=1}^{N} a_{ij}(x,u)\frac{\partial^2 u}{\partial x_i \partial x_j} + c(x,u)u = f(x,u,\nabla u)$$

on a bounded smooth domain Ω in R^N with $c(x,r) \geqslant \alpha_0$ and $|f(x,r,\xi)| \leqslant C_0 + h(|r|)|\xi|^\theta, 0 \leqslant \theta < 2$, we note that every solution $u \in W^{2,p}(\Omega) \cap W_0^{1,p}(\Omega), p \geqslant \frac{2N}{N+2}$, is L^∞ -bounded by $\frac{C_0}{\alpha_0}$. Consequently, the existence of such solution is irrelevant to $a_{ij}(x,r)$ on $|r| \geqslant \frac{C_0}{\alpha_0}$. It is then shown that if the oscillation $a_{ij}(x,r)$ with respect to r are sufficiently small for $|r| \leqslant \frac{C_0}{\alpha_0}$, then there exists a solution $u \in W^{2,p}(\Omega) \cap W_0^{1,p}(\Omega), 1 \leqslant p < \infty$.

Connecting orbits in analytical sine-like delay equations

by *Bernhard Lani-Wayda*

We construct explicit analytical examples of delay equations $x'(t) = f(x(t-1))$ with periodic and odd f, which possess an attractive pair of orbits homoclinic to a saddle. Dynamical consequences of this situation as well as the relation to numerical observations are discussed.

Classical solutions for non–elliptic Euler–Lagrange equations via continuation

by *Timothy J. Healey, Hansjörg Kielhöfer and Markus Lilli*

We prove existence of classical solutions of an Euler–Lagrange equation arising from a 1–d non–convex variational problem in nonlinear elasticity. Therefore we consider a physically reasonable stored–energy density W such that $W(\nu)$ goes to infinity for $\nu \searrow 0$ and $\nu \to \infty$. We introduce a singular perturbation in order to obtain an elliptic EL–equation and we prove existence of solutions by Leray–Schauder degree. Moreover the solution is strictly bounded away from 0 and by the continuation method we derive certain features of the solution which allows us to pass to the limit in some appropriate Sobolev–space.

Numerical approximation of singular boundary value problems for a nonlinear differential equation

by *Pedro M. Lima and Luisa M. Morgado*

In this work, we are concerned about the nonlinear second order differential equation

$$y''(x) + (N-1)/xy'(x) = c(x)y(x)(y(x)+1)(y(x)-\xi),$$

where $N > 1, \xi > 0$, $c(x)$ is an even analytical function on $[0,\infty[$, such that $0 < c_1 \leq c(x) \leq c_2$, $\forall x \in R^+$, for some real numbers c_1, c_2. We search for solutions of this equation which satisfy the boundary conditions

$$y'(0) = 0, \qquad y(M) = \xi, \quad M \in R^+ \qquad \text{or} \quad y'(0) = 0, \qquad \lim_{x\to\infty} y(x) = \xi.$$

In [1] the authors have analysed a particular case of the second problem when $c(x) \equiv 1$. The behavior of the solutions near the singularities has been investigated and a stable numerical algorithm was introduced. Here we extend the results obtained in [1] to the first problem and to the case when $c(x)$ is an even analytical function.

[1] P. M. Lima, N. B. Konyukhova, A. I. Sukov and N. V. Chemetov, Analytical-numerical investigation of bubble-type solutions of nonlinear singular problems, submitted to *Journal of Computational and Applied Mathematics*.

Arbitrary Lagrangian Eulerian method for compressible plasma simulations

by *Richard Liska and Milan Kuchařík*

Many problems in compressible fluid modeling involve large scale compression or expansion regimes with moving boundaries cannot be numerically treated on static Eulerian computational mesh and are typically simulated on Lagrangian mesh moving with the fluid. In some cases, as e.g. simulations involving shear waves or physical instabilities, the Lagrangian moving mesh becomes distorted by fluid movement so much that some cells are inverted and Lagrangian computation cannot continue. Such problems can be treated by Arbitrary Lagrangian Eulerian (ALE) method which after several Lagrangian time steps smooths the mesh and remaps conservative quantities from the old mesh to the smoother one. We have developed the 2D ALE code on quadrilateral, logically rectangular meshes. The code is targeted to laser plasma applications which typically involve compression and expansion regimes with moving boundaries which cannot be treated by standard Eulerian methods. High velocity laser accelerated disc impact problems for which standard Lagrangian simulation method fails are treated well by the ALE method.

Discretizations of ODE's near some bifurcation points

by *Lajos Lóczi*

In this talk we present three case studies in the numerics of bifurcating one-parameter families of one-dimensional ordinary differential equations. Our aim is to compare—for fixed $h > 0$ sufficiently small—the one-parameter family of time-h-maps of the ODE's and the one-parameter family of their stepsize-h discretizations, in the vicinity of *fold*, *transcritical* or *pitchfork* bifurcation points. The two families are proved to be topologically equivalent. The corresponding conjugacies depend continuously on the parameters and are $\mathcal{O}(h^p)$-perturbations of the identity, where $p \geq 1$ is the order of the discretization. The results are lifted to bifurcating systems of ODE's with equilibria losing stability.

Nucleation of small balls for the Landau Ginzburg functional

by *Stephan Luckhaus (joint work with G. Bellettini, M. Gelli and M. Novaga)*

Motivated by results of R. Kotecky and D. Ioffe in statistical mechanics,we look at the nucleation threshold for the Landau Ginzburg functional and show that to first order it is the same as for the free energy with surface tension. The result requires a finer estimate than the γ limit. It is more in the spirit of a γ expansion.

Large time behaviors of derivatives of the vorticity for the two dimensional Navier–Stokes flow

by *Yasunori Maekawa*

In this talk we will discuss the large time asymptotic behaviors of derivatives of the vorticity solving the two dimensional vorticity equation which is formally equivalent to the Navier–Stokes equation. It is known by now that the vorticity behaves asymptotically as the Oseen vortex provided that the initial vorticity is integrable. We will show that each derivative of the vorticity also behave asymptotically as that of the Oseen vortex. For the proof we will establish new spatial decay estimates for derivatives of the vorticity. The convergence result follows from a rescaling and compactness argument.

Stationary isothermic surfaces

by *Rolando Magnanini*

A stationary isothermic surface is a spatial level surface of temperature that is invariant with time. In two important situations, I will show how the existence of one stationary isothermic surface implies (i) that all isothermic surfaces are stationary; (ii) a certain symmetry of temperature. I will also exhibit an example in which (i) does not hold, that is an isolated isothermic surface can occur.

Global regularity of the 3D Navier–Stokes equations with uniformly large initial vorticity

by *Alex Mahalov*

We prove existence on infinite time intervals of regular solutions to the incompressible 3D Navier–Stokes Equations for fully three-dimensional initial data characterized by uniformly large initial vorticity; smoothness assumptions for initial data are the same as in local existence theorems. There are no conditional assumptions on the properties of solutions at later times, nor are the global solutions close to any 2D manifold. The global existence is proven using techniques of fast singular oscillating limits and the Littlewood–Paley dyadic decomposition. The approach is based on the computation of singular limits of rapidly oscillating operators and cancellation of oscillations in the nonlinear interactions for the vorticity field. With nonlinear averaging methods in the context of almost periodic functions, we obtain fully 3D limit resonant Navier–Stokes equations. We establish the global regularity of the latter without any restriction on the size of 3D initial data. With strong convergence theorems, we bootstrap this into the global regularity of the 3D Navier–Stokes equations with uniformly large initial vorticity.

Non blow-up of the 3D Euler equations for a class of three-dimensional initial data in cylindrical domains

by *Alex Mahalov*

Non blow-up of the 3D incompressible Euler Equations is proven for a class of three-dimensional initial data characterized by uniformly large vorticity (background rotation) in bounded cylindrical domains. There are no conditional assumptions on the properties of solutions at later times, nor are the global solutions close to some 2D manifold. The approach of proving regularity is based on investigation of fast singular oscillating limits and nonlinear averaging methods in the context of almost periodic functions. We establish the global regularity of the 3D limit resonant Euler equations without any restriction on the size of 3D initial data. After establishing strong convergence to the limit resonant equations, we bootstrap this into the regularity on arbitrary large time intervals of the solutions of 3D Euler Equations with weakly aligned uniformly large vorticity at $t = 0$.

On the existence of Hopf bifurcation in an open economy model

by *Katarína Makovinyiova and Rudolf Zimka*

In the paper a four dimensional open economy model describing the development of output, exchange rate, interest rate and money supply is analysed. Sufficient conditions for the existence of equilibrium, its stability and the existence of business cycles are found.

Boundary value problems in Banach spaces: a bound sets approach

by *Luisa Malaguti*

The talk deals with the semi-linear differential inclusion

$$\dot{x}(t) + A(t)x(t) \in F(t, x)$$

in a separable reflexive Banach space E. We assume $A : t \to \mathcal{L}(E)$ measurable and Bochner integrable on compact domains and we take an upper-Carathéodory multi-function F.

We propose existence results of periodic and antiperiodic trajectories.

We show the employed techniques, based on a continuation principle proposed by *Andres-Gabor-Górniewicz* in Euclidean spaces and then generalized in Frechét spaces by *Andres-Bader*. We discuss a bound sets approach used in this framework in order to guarantee the required transversality conditions.

Finally, we show the existence of bounded solutions obtained by a sequential approach from the solutions of suitable Cauchy problems.

The work is a joint research with *Jan Andres* from Palacký University of Olomouc (Czech Republic) and *Valentina Taddei* from Siena University (Italy).

Crystallographic pinning in lattice differential equations

by *John Mallet-Paret*

A lattice differential equation is an infinite system of ordinary differential equations coordinatized by points on a spatial lattice (for example, the integer lattice $Z^n \subseteq R^n$). Typically such systems exhibit a rich variety of dynamic phenomena, including patterns, traveling waves, and spatial chaos. Crystallographic pinning, the phenomenon in which waves become pinned (that is, cease moving) in selected directions in the lattice, is of particular interest.

We describe recent results in this field. In particular, we see that crystallographic pinning is characterized by an infinite system of layer equations, which are in fact functional differential equations of mixed type. For the lattice Z^2, crystallographic pinning is generic, and corresponds to certain homoclinic solutions of the layer equations. On the other hand, for lattices in higher dimensions R^n, one must generically consider $(n-1)$-heteroclinic cycles of solutions.

Tools of dynamical systems, including results on invariant manifolds and bifurcation techniques, are used. This is in part joint work with Aaron Hoffman.

Singular state-dependent delay equations: asymptotics and stability

by *John Mallet-Paret*

In earlier work with Roger Nussbaum, we studied the limiting shape of solutions to singularly perturbed state-dependent delay equations, such as

$$\varepsilon \dot{x}(t) = f(x(t), x(t-r)), \qquad r = r(x(t)).$$

Here we extend this work, and study the detailed asymptotics of these solutions. Such an analysis is important in obtaining stability results, as well as results for problems with multiple delays. Techniques and ideas from geometric singular perturbations are used in our analysis.

Different scalings in homogenisation of reaction, diffusion and interfacial exchange in a two-phase medium

by *Malte A. Peter and Michael Böhm*

We consider a coupled system of parabolic partial differential equations in a two-phase medium in the context of homogenisation. From a modelling point of view, there is some freedom of choice regarding the scaling of the coefficients of the microscopic problem with powers of the homogenisation parameter. It is shown that, starting with a certain problem on the microscopic scale, different choices of scaling of the diffusion coefficients and of the interfacial-exchange coefficient lead to different types of homogenised macroscopic systems of equations. Using the method of two-scale convergence, a unified and comprehensive approach yielding rigorous proofs is given covering a very broad class of different scalings. As special cases for certain particular scalings, recent results from the literature are recovered and classical parallel-flow-type models and distributed-microstructure models are obtained.

On constructing a solution of a boundary value problem for functional differential equations

by *Lukáš Maňásek*

Consider the functional differential equation

$$x'(t) = F(x)(t), h(x) = 0 \tag{1}$$

upon closed interval I, where $F : C([I; R^n]) \longrightarrow L(I; R^n)$ is a regular operator (fulfiling Caratheodory conditions) and $h : C([I; R^n]) \longrightarrow R^n$ is a continuous functional. The sequence of the solution corresponding to Cauchy's problems, which converges to the solution to the problem (1), is used for constructing this solution.

This article extends and complements the results of I. Kiguradze ([1], [2]) dealing with Cauchy-Nicolett's problems for an ordinary differential equation and for a differential equation with deviating arguments. The bound of a generalized method of theoretic approximation is determined by Cauchy's problems, among others. Methods and results are illustrated by examples (including numeric solutions to definite problems).

[1] I. Kiguradze, *Boundary value problems for systems of ordinary differential equations*, Itogi Nauki Tekh., Ser. Sovrem. Provl. Mat., Novejshie Dostizh. 30 (1987)

[2] I. Kiguradze, *Initial and boundary value problems for systems of ordinary differential equations*, Metsniereba, Tbillisi (1997)

Finite speed of propagation in monostable degenerate reaction-diffusion-convection equations

by *Cristina Marcelli*

The talk concerns the existence and properties of travelling wave solutions of the Fisher-KPP reaction-diffusion-convection equation $u_t+h(u)u_x = [D(u)u_x]_x+g(u)$, where the diffusivity $D(u)$ is simply or doubly degenerate. We discuss the effects, due to the presence of a convective term, concerning the phenomenon of finite speed of propagation. Moreover, in the doubly degenerate case we show the appearance of new types of profiles and provide their classification according to sharp relations between the nonlinear terms of the model.

Riccati technique for half-linear PDE

by *Robert Mařík*

Various applications of Riccati transformation will be used for establishing oscillation criteria and some results concerning asymptotics for second order half-linear partial differential equation

$$\text{div}(||\nabla u||^{p-2}\nabla u) + c(x)|u|^{p-2}u = 0$$

and several other equations of a similar form.

Complete and incomplete blow-up in a nonlinear heat equation

by *Hiroshi Matano*

We consider blow-up phenomena for the semilinear heat equation

$$u_t = \Delta u + u^p,$$

where we assume that the exponent p is Sobolev supercritical, namely $p > p_s := \frac{N+2}{N-2}$, $N \geq 3$, and the solution is radially symmetric.

In this range of p it is known that the so-called "incomplete" blow-up can occur. Here a blow-up is called *complete* if the solution satisfies $u = \infty$ everywhere immediately after the blow-up time.

In this lecture I will first recall basic properties of complete and incomplete blow-ups, some of which are known and some are new. I will then discuss the behavior of solutions whose initial data are of the form

$$u(x, 0) = \lambda\, v(x),$$

where $v \geq 0, \not\equiv 0$, $v \in H^1 \cap L^\infty$ and λ is a positive parameter. Among other things we will show that there exists a critical value $\lambda^* > 0$ such that the solution is globally classical if $0 < \lambda < \lambda^*$ and blows up in finite time if $\lambda \geq \lambda^*$. At the threshold $\lambda = \lambda^*$, the blow-up is always incomplete, but whether the blow-up rate is of type I or type II depends on p. If $\lambda > \lambda^*$, with at most finitely many exceptional values of λ, the blow-up is always complete and type I. Most of the results presented here are a joint work with Frank Merle.

Existence, uniqueness and regularity of the solution of the string–beam system

by *Aleš Matas*

The talk will be devoted to the summary of the results proved for the mathematical model related to the modelling of suspension bridges. The model is formulated as an initial-boundary value problem for a system of partial differential equations. The existence, regularity and uniqueness of the weak solution on the vector-valued Lebesgue spaces are studied. As the main tools in the proofs, we use the Faedo-Galerkin method and the a priori estimates.

Travelling waves in heterogenous media and exponential averaging

by *Karsten Matthies*

Travelling waves can become pinned or modulated in reaction diffusion equations on unbounded cylindrical heterogenous media. The presence of small scale structures in the medium can cause failure of propagation ('pinning') so that rather than having travelling waves one has stationary, spatially localised solutions. Using a description of the elliptic equation on the unbounded domain as an (ill-posed) evolution equation and exponential averaging techniques, we show that pinning occurs in periodic media in only very small ranges of parameters. With similar techniques, it is also possible to describe the periodic modulation of travelling waves up to very small errors.

Boundary value problems for strongly nonlinear differential inclusions

by *Nikolaos M. Matzakos*

Here examine nonlinear differential inclusions with Dirichlet boundary conditions a forcing term with no growth restrictions and satisfying instead a generalized sign condition.

$$\left\{ \begin{array}{l} a(t,x(t),x'(t))' - \partial\varphi(x(t)) - F(t,x(t)) \ni h(t) - \beta x'(t) \text{ a.e on } T=[0,b] \\ x(0)=x(b)=0. \end{array} \right\}$$

Here $a : T \times \mathbb{R} \times \mathbb{R} \to 2^{\mathbb{R}}$ and $F : T \times \mathbb{R} \to 2^{\mathbb{R}}$ are multifunctions and $\partial\varphi(x)$ is the subdifferential of the convex function $\varphi(\cdot)$.

Using techniques from multivalued analysis and theory of nonlinear operators of monotone type, we establish the existence of a solution.

Nonlinear integral inequalities with singular kernels and their applications

by *Milan Medveď*

The talk is devoted to the following nonlinear integral inequality

$$u(t)^r \leq a(t) + \int_0^t (t-s)^{\beta-1} F(s)\omega(u(s))ds,$$

where $0 < \beta < 1, r \geqq 1, a(t), F(t)$ are continuous, nonnegative functions, $a(t)$ is nondecreasing, and $\omega > \langle 0, \infty) \to R$ is continuous, nonnegative, nondecreasing function. We give a proof of an inequality of the Gronwall-Bihari type and point out some applications of this inequality, e.g. to the study of the existence of global solutions of nonlinear integral equations with singular kernels.

A distributed-microstructure model for diffusion and reaction in porous media

by *Sebastian A. Meier and Michael Böhm*

Diffusion, absorption and chemical reaction of a gas in a porous medium is described by a *distributed-microstructure model*. The general model consists of a parabolic equation weakly-coupled with a set of semilinear parabolic systems that are defined on local unit cells and describe effects on the microscale. This concept has been investigated before by Showalter et al. in the context of flow in fissured media and is also known in computational mechanics as the FE^2 model. In special cases, such models can be obtained by periodic homogenisation of purely microscopic models.

In the present situation, the reaction-diffusion system is shown to be wellposed using energy methods and a fixed-point principle. Special attention is paid to the construction of spaces of functions defined on the local cells. They are constructed as a *direct integral* of corresponding Sobolev spaces to account for a varying local geometry. For a special case where the equations are linear, an approximating kinetic model of Nth order can be derived. The latter system allows an effective numerical solution.

The general system is suitable, for instance, to describe phase changes in concrete structures due to the aggression of chemical species.

Energetic formulation of hysteresis problems, existence and uniqueness

by *Alexander Mielke*

We consider the energetic formulation of rate-independent hysteresis problems. It is based on an energy-storage functional $\mathcal{E}$ and a dissipation distance $\mathcal{D}$ or, in the case of an underlying space with differentiable structure, by a dissipation potential $\mathcal{R}$ which is homogeneous of degree 1 in the rate.

The formulation is either in terms of *stability* (S) and *energy balance* (E)

(S) $\mathcal{E}(t, y(t)) \leq \mathcal{E}(t, \widetilde{y}) + \mathcal{D}(y(t), \widetilde{y})$ for all $\widetilde{y} \in \mathcal{Y}$;
(E) $\mathcal{E}(t, y(t)) + \mathrm{Diss}_{\mathcal{D}}(y; [s, t]) = \mathcal{E}(s, y(s)) + \int_s^t \partial_\tau \mathcal{E}(\tau, y(\tau))\,\mathrm{d}\tau.$

or in terms of a differential inclusion

$$0 \in \partial\mathcal{R}(y(t), \dot{y}(t)) + \mathrm{D}\mathcal{E}(t, y(t)),$$

Existence is obtained by time-incrmental minimization problems and passage to the limit performed by suitable compactness assumptions. This part follows ideas of M. & Theil [1999,2001/4] and Mainik & M. [2005]

Uniqueness results are obtained under the assumptions of convexity of the energy $\mathcal{E}(t, \cdot)$ and of smoothness of the energy and the dissipation potential $\mathcal{R}$. The most important condition is that the Lipschitz constant of $\mathcal{R}(\cdot, \dot{y})$ is small compared to the uniform convexity of $\mathcal{E}$. This work is based on recent work with Riccarda Rossi and relates to Brokate, Krejčí& Schnabel [2004].

Delay logistic model with control parameter

by *José J. Miguel*

It is common in practice to assume, for example, that the rate at which a population grows at time t depends on the magnitude of the population at same time. In this paper logistic delay differential equations with discrete delay will be discussed. For illustration two models with constant H and proportional kx harvesting will be used as control factors.

$$\frac{dx}{dt} = cx(t)\left(1 - \frac{x(t-\tau)}{x_*}\right) - H \tag{1}$$

In the fields of biology and ecology, the first appearance of the discrete delayed logistic, equation (1), (without control term H), was in publication by Hutchinson [1]. In that epic paper, Hutchinson expressed the view that the observed oscillations in some kinds of biological populations could be explained by a discrete time delay in the crowding or resource term.

The aim of this paper is to find the optimal harvesting value - control parameter.

[1] Banks R. B.: *Growth and Diffusion Phenomena. Mathematical frameworks and applications.* Spring-verlag, Berlin. 1994.

[2] Shampine L.F.: *Solving DDE's in MATLAB using dde23.* Matlab News and Notes

[3] Kolmanovsky V. B., Nosov V. R: *Stability of functional differential equation*. Academic Press Inc. 1986

Method of homogenization applied to dispersion, convection and reaction in porous media

by *Andro Mikelic*

The homogenization technique, which is a rigorous method of averaging by multiple scale expansions, is applied to the transport of reacting solute in a porous medium. We focus our attention on situations when Peclet's and Damkohler's numbers are important. Starting from the pores, with the usual convection-diffusion equation for the solute and a first-order chemical reaction for the solute particles at the pore boundaries, we give a derivation of the 3D dispersion tensor for solute concentration. For particular pore geometry and particular scaling, we find the well-known Taylor dispersion formula. Our approach allows handling higher Peclet numbers than in the literature. For important Damkohler's number, our method gives important corrections in the upscaled transport and reactive terms.

Finite volume methods in image processing

by *Karol Mikula*

In many applications computers analyse images quality of which can be poor, e.g., they are contaminated by a noise and/or boundaries of image objects are partly missing (e.g. in medical imaging, in scene with occlusions or illusory contours). We will discuss application of finite volume schemes to solving nonlinear partial differential equations arising in image selective smoothing and segmentation tasks. The numerical schemes will be applied to the regularized Perona-Malik equation and to the curvature driven level set equation used in image smoothing as well as to the Riemannian mean curvature flow of graphs used in image segmentation. The convergence of the schemes to solution of PDEs as well as computational results in bio-medical image processing will be presented.

On the Shockley-Read-Hall model: Generation-Recombination in Semiconductors

by *Vera Miljanovic*

A model for the flow of electrons in a semiconductor crystal, incorporating the effects of recombination-generation via traps distributed in the forbidden band is considered. In mathematical terms it consists of a reaction-diffusion-convection equation for the density of the conduction electrons, nonlinearly coupled to a Poisson equation for the potential and an integro-differential equation for the distribution of occupied traps. Rigorous derivation for the drift-diffusion model is done.

Cross-diffusion systems in biology

by *Masayasu Mimura*

In the field of population dynamics, some models of competing species are described by reaction-diffusion systems. Among them, there is a system which is taken into account the population pressure created by the competitors. It is called a cross-diffusion and competition system in mathematical biology. This system, especially, the global structures of equilibrium solutions have been investigated in nonlinear PDE communities. From the biological motivation, we discuss that such a cross-diffusion system can be approximated by a kind normal diffusion system, taking some singular limit. This is a joint work with H. Ninomiya (Ryukoku Univ.) and M. Iida (Iwate Univ.).

Transient pattern formation in reaction-diffusion systems

by *Masayasu Mimura*

It has been revealed analytically and complementarily numerically that far from equilibrium (or open) systems have generated diverse complex spatio-temporal patterns in reaction-diffusion (RD) model equations. On the contrary, we have believed that closed RD equations are less interesting from pattern formation viewpoints. In this talk, I emphasize that this belief is not necessarily true and that such equations possibly generate complex patterns in transient behaviors, although their asymptotic behaviors are quite simple. I order to discuss it, I introduce several phenomena and related models arising in chemistry and biology.

On a system of nonlinear PDEs with hysteresis effect

by *Emil Minchev*

The present talk deals with results for boundedness and existence of solution of a nonlinear system of PDEs with hysteresis effect.

Lower and upper solutions method for a fully nonlinear elastic beam equation simply supported

by *Feliz Minhós*

An existence and location result for the fourth order boundary value problem

$$u^{iv} = f\left(t, u, u', u'', u'''\right), \quad 0 < t < 1,$$

with the boundary conditions

$$u\left(0\right) = u''\left(0\right) = u\left(1\right) = u''\left(1\right) = 0,$$

where $f : [0,1] \times \mathbb{R}^4 \to \mathbb{R}$ is a continuous function satisfying a Nagumo type condition. The usual monotonicity assumptions are not needed.

Blowup problem for a supercritical heat equation

by *Noriko Mizoguchi*

We are concerned with the blowup phenomena of a Cauchy problem for a semilinear heat equation

$$\begin{cases} u_t = \Delta u + u^p & \text{in } \mathbf{R}^N \times (0,\infty), \\ u(x,0) = u_0(x) \geq 0 & \text{in } \mathbf{R}^N \end{cases}$$

with $p > 1$ and $u_0 \in L^\infty$. The situation for supercritical p in the Sobolev sense is quite different from that in the subcritical case from various viewpoints such as type II blowup (i.e., blowup at faster rate than that of $u_t = u^p$) and incomplete blowup. Herrero and Velázquez showed the existence of a type II blowup solution for $p > p_*$, where

$$p_* = \begin{cases} +\infty & \text{if } N \leq 10, \\ 1 + \dfrac{4}{N - 4 - 2\sqrt{N-1}} & \text{if } N > 10. \end{cases}$$

We apply their method to evaluate the blowup rate of solutions which exhibit type II blowup and to obtain a weak solution with multiple blowup time.

On third order advanced nonlinear differential equations

by *Ivan Mojsej and Ján Ohriska*

We consider the third-order nonlinear differential equations with deviating argument of the form

$$\left(\frac{1}{p(t)}\left(\frac{1}{r(t)}x'(t)\right)'\right)' + q(t)f(x(h(t))) = 0\,, \quad t \geq 0 \tag{1}$$

and

$$\left(\frac{1}{r(t)}\left(\frac{1}{p(t)}z'(t)\right)'\right)' - q(t)f(z(h(t))) = 0\,, \quad t \geq 0 \tag{2}$$

in so called canonical form, i. e. in the case $\int^{\infty} r(t)\,dt = \int^{\infty} p(t)\,dt = \infty$. The aim of this report is to present some oscillatory and asymptotic properties of solutions of equations (1) and (2). In particular, comparison results for properties A and B are stated. Obtained results extend some other ones known for nonlinear differential equations without deviating argument.

A characterization of convex φ-calibrable sets in $\mathbb{R}^N$

by *V. Caselles, A. Chambolle, M. Novaga and S. Moll*

The main purpose of this paper is to characterize the calibrability of bounded convex sets in $\mathbb{R}^N$ by the mean curvature of its boundary, extending the known analogous result in dimension 2. As a by-product of our analysis we prove that any bounded convex set C of class $C^{1,1}$ has a convex φ-calibrable set K in its interior, and and for any volume $V \in [|K|, |C|]$ the solution of the φ-perimeter minimizing problem with fixed volume V in the class of sets contained in C is a convex set. As a consequence we describe the evolution of convex sets in $\mathbb{R}^N$ by the minimizing anisotropic total variation flow.

Navier–Stokes equations in Lipschitz domains

by *Sylvie Monniaux*

We show that the Navier–Stokes equations have a unique local strong solution in a bounded Lipschitz domain $\Omega \subset \mathbb{R}^3$ provided the initial data belongs to the space $D(A^{\frac{1}{4}})$ where A is the Stokes operator in $\mathcal{H} = \{u \in L^2(\Omega)^3 : \langle u, \nabla\phi\rangle = 0 \; \forall\; \phi \in W^{1,2}(\Omega)\}$. If the norm of the initial data is small enough, we can prove that the solution is global. This result improves the former result by Deuring and von Wahl in 1995 where they assumed that the initial data was in $D(A^{\frac{1}{4}+\varepsilon})$ for $0 < \varepsilon < \frac{1}{4}$.

Analytical-numerical approach to singular boundary value problems for an Emden-Fowler equation

by *M. L. Morgado and P. M. Lima*

In this work we are concerned about a second order nonlinear ordinary differential equation, known in the literature as Emden-Fowler equation:

$$g''(u) = au^{\sigma} g^{n}(u), \;\; 0 < u < u_0,$$

where $n < 0, a < 0$ and σ are given real numbers. Our main purpose is to describe one-parameter families of solutions of this equation which satisfy the following conditions:

$$\lim_{u \to u_0 -} g(u) = \lim_{u \to u_0 -} (u - u_0) g'(u) = 0, \;\; u_0 > 0;$$

$$\lim_{u \to 0+} g(u) = \lim_{u \to 0+} u g'(u) = 0.$$

The mentioned one-parameter families of solutions are obtained in the form of asymptotic or convergent series. These series expansions are then used to approximate the solutions of the following boundary value problems:

$$\lim_{u \to 0+} g'(u) = 0; \;\; \lim_{u \to u_0 -} g(u) = \lim_{u \to u_0 -} (u - u_0) g'(u) = 0 \;\; ;$$

$$\lim_{u \to 0+} g(u) = \lim_{u \to 0+} u g'(u) = 0; \;\; \lim_{u \to u_0 -} g(u) = \lim_{u \to u_0 -} (u - u_0) g'(u) = 0.$$

We are specially interested in the case of negative n, when both problems are degenerate with respect to g. Moreover, if $\sigma < 0$, the problems are also degenerate with respect to u, as $u \to 0$. Lower and upper solutions for each of these boundary value problems are obtained and, in certain particular cases, a closed formula for the exact solution is derived. Numerical results are presented and discussed.

Some entire solutions to reaction-diffusion equations with bistable nonlinearity

by *Yoshihisa Morita*

We are dealing with a reaction-diffusion equation $u_t = u_{xx} + f(u)$ which possesses traveling front solutions connecting two stable equilibria $u = 0, u = 1$. We call an entire solution to this equation if it is a bounded solution defined for all $(x,t) \in \mathbf{R}^2$. Besides equilibrium solutions and traveling front solutions, there exist another type of entire solutions to this equation. In fact we show the existence of entire solutions which are characterized by the asymptotic behavior as $t \to -\infty$ in terms of combinations of traveling fronts solutions. The main result is proved by using the comparison principle.

On a linear approximation scheme to the classical Stefan problem

by *Hideki Murakawa*

When dealing with nonlinear problems, one usually tries to linearize them so as to take advantage of efficient linear solvers from a numerical point of view. The aim of this talk is to propose a linear approximation scheme to the classical Stefan problem. Applying the operator-splitting methodology to a certain reaction-diffusion system and taking the singular limit in the splitting scheme, we obtain a linear approximation scheme to the Stefan problem. The main process of the scheme is just to solve the linear heat equations. We can construct a numerical scheme to the Stefan problem by using a numerical method for the linear heat equations. Using efficient linear solvers we can implement the scheme easily. The scheme naturally handles complicated topological changes in several dimensions.

Traveling wave solutions and propagation phenomena in gradient reaction-diffusion systems

by *Cyrill B. Muratov*

Gradient reaction-diffusion systems arise in the context of modeling the kinetics of second-order or weakly first-order phase transitions, with a broad range of applications. These systems are known to exhibit a variety of non-trivial spatio-temporal behaviors, most notably the phenomenon of propagation and traveling waves. We introduce a variational formulation for the traveling wave solutions in cylindrical geometries, which allows us to construct a certain class of special traveling wave solutions and study a number of their properties. These solutions are special in a sense that they are characterized by a non-generic fast exponential decay ahead of the wave and play an important role in propagation phenomena for the initial value problem. In particular, we show that no solution of the initial value problem that is initially sufficiently localized can propagate faster than the speed of the obtained traveling wave. We also show that only this type of traveling wave solutions can be selected as the asymptotic limit of the solution in the reference frame associated with its leading edge at long times. The considered variational formulation gives easily verifiable upper and lower bounds for propagation speeds. This is joint work with M. Lucia and M. Novaga.

Approximations for some diffusion and interface problems using singular limit technique

by *Tatsuyuki Nakaki and Hideki Murakawa*

Approximations, which are useful and effective for numerical simulations, are proposed. The approximations are constructed by using singular limit solutions of certain reaction-diffusion equations. First example is Stefan problem. We can easily and clearly capture the interfaces in multi-dimensional space by using the approximation. Another example is a nonlinear diffusion equation. The approximation also works well, and we obtain good numerical solution with comparatively low computational cost. In this talk, we discuss the approximations and demonstrate some numerical simulations.

On the steady fall of a rigid body in linear viscous fluid

by *Šárka Nečasová*

We deal with the equations describing the falling body in a viscous fluid. We are interested in the existence, uniqueness and asymptotic behavior of solution of the problem. We consider the case when the body rotates and we assume that the angular velocity of body is linear to gravity.

The beam operator and the Fučík spectrum

by *Petr Nečesal*

We try to find the way how to explore the complex structure of the Fučík spectrum for the beam operator $u \mapsto -(u_{tt} + u_{xxxx})$. As a first step, we design some numerical approaches how to find the Fučík curves for the wave operator $u \mapsto -(u_{tt} - u_{xx})$. Numerical experiments point out qualitatively different behaviour of the Fučík spectrum and its corresponding generalized eigenfunctions in the case of the wave operator in contrast with known results concerning the Fučík spectrum for ordinary differential operators. Moreover, results of numerical experiments that involve unknown branches of the Fučík spectrum are useful for better understanding of the structure of PDE models such as nonlinear model of a suspension bridge.

On the solvability of a class of stationary generalized Stokes problem

by *Nguyen Duc Huy and Jana Stará*

We investigate existence and uniqueness of weak solutions for a type of generalized Stokes problem. The generalization we consider here consists in two points: A Laplacian is replaced by a general second order linear elliptic operator in divergence form and ”pressure” gradient ∇p is replaced by a linear operator of first order with constant coefficients.

The influence of diffusion and boundary conditions on blowup

by *Hirokazu Ninomiya*

In this talk we consider the blowup problem of a reaction-diffusion equation or system. One may not think that the diffusion plays important role in the occurrence of blowup. It is known that adding diffusion induces blowup in some systems. The influence of the boundary conditions is discussed in this talk. Suppose that we have a reaction-diffusion equation or system such that some solutions which are homogeneous in space blow up in finite time. Is it possible to inhibit the occurrence of blow-up as a consequence of imposing boundary conditions, or of other effects where diffusion plays a role? Some examples of equations and systems where the answer is affirmative are presented.

Vortices for some self-dual gauge field models

by *Margherita Nolasco*

We consider multivortex solutions for Abelian Higgs and Chern-Simons self-dual models using a gluing technique (shadowing lemma) for the corresponding semilinear elliptic equations on the plane. In particular, we prove a factorization formula for multivortex solutions, up to an error which is exponentially small as the ratio of the vortex core size to the separation distance between vortex points tends to zero.

Crystalline evolutions of convex sets

by *Matteo Novaga*

I will discuss a local existence and uniqueness result for crystalline mean curvature flow starting from a compact convex set in $\mathbf{R}^N$. This result can be generalized to any anisotropic mean curvature flow. The method also provides a generalized geometric evolution starting from any compact convex set, existing up to the extinction time, satisfying a comparison principle, and defining a continuous semigroup in time. Moreover, when the initial set is convex, such evolution coincides with the flat curvature flow in the sense of Almgren-Taylor-Wang. As a by-product, it turns out that the flat curvature flow starting from a compact convex set is unique.

On a degenerate Allen-Cahn/Cahn-Hilliard system

by *Amy Novick-Cohen*

A degenerate Allen-Cahn/Cahn-Hilliard system is considered which couples fourth order and second order dynamics. Formally it is possible to demonstrate that in a long time scaling limit, the predicted motion should be given by combined surface diffusion and motion by mean curvature which couple at triple junction. The angles governing the structure of the triple junction are determined by the underlying free energy. We explore the variational considerations which determine these angles, and in particular focus on possible degeneracies which may occur, and how this is related to wetting and prewetting.

On a numerical scheme for the Willmore flow

by *Tomáš Oberhuber*

The contribution deals with the Willmore flow of graphs which is described by the relaxation of a functional depending on the mean curvature. We describe a numerical scheme based on the method of lines. The spatial derivatives are discretized by the finite-difference method on a uniform grid and the resulting system of ODEs is solved by the Runge-Kutta method. We deliver several qualitative examples of computation using the derived scheme as well as numerical studies of convergence demonstrating ability of the scheme.

Multiple solutions of nonlinear BVPs for equations with critical points

by *Svetlana Ogorodnikova*

We obtain multiplicity results for the BVP

$$x'' = f(t,x), \quad x(0) = x(1) = 0,$$

provided that a function $f(t,x)$ behaves similarly to either the function $f_1 = -\alpha x + x^3$ or the function $f_2 = -\alpha x + x^2$. We are motivated by the respective autonomous equations with critical points. Our estimates from below of the number of solutions are precise. Analogous results are proposed for the fourth order BVPs which include as a model case the problem $x^{(4)} = -\alpha x - x^3$, $x(0) = x'(0) = 0 = x(1) = x'(1)$.

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S. Ogorodnikova and F. Sadyrbaev: Planar systems with critical points: multiple solutions of two-point nonlinear boundary value problems. Proc. Fourth World Congress Nonlinear Analysts, Orlando, FL, USA, June 30–July 7, 2004.

Non-autonomous boundary value problems on the real line

by *Francesca Papalini*

We prove existence and non-existence results for the non-autonomous boundary value problem for second order differential equations of the type:

$$\left\{ \begin{array}{l} (\Phi(x'(t)))' = f(t, x(t), x'(t)), \text{ a.e. on } \mathbb{R} \\ x(-\infty) = 0, x(+\infty) = 1 \end{array} \right\},$$

in which the usual linear differential operator $x \to x''$ is replaced by the operator $x \to (\Phi(x'))'$, where $\Phi : \mathbb{R} \to \mathbb{R}$ is a monotone function which generalizes the so called one-dimensional p-Laplacian operator.

If the right-hand side of the equation has the product structure $f(t, x, x') = a(t, x)b(x, x')$ then we deduce operative criteria for the existence and non-existence of solutions. Crucial in our considerations is the relation between the behavior of $a(., x)$ when $|t| \to +\infty$ and the behavior of $b(x, .)$ with respect to $|\Phi(x')|$ when $x' \to 0$.

Oscillation and nonoscillation criteria for retarded functional differential equations

by *Ana M. Pedro*

Several criteria are given for having the retarded functional differential equation $\frac{d}{dt}x\left(t\right) = \int_{-1}^{0} x\left(t - r\left(\theta\right)\right) dq\left(\theta\right)$ either oscillatory or nonoscillatory, depending upon the smoothness of the delay function $r\left(\theta\right)$.

Numerical blow-up for the p-Laplacian equation with a source

by *Raúl Ferreira, Arturo de Pablo and Mayte Pérez-Llanos*

In the following work several numerical aspects of blow-up for a quasilinear parabolic equation with the p-laplacian operator are analyzed. More precisely, we study numerical approximations of positive solutions of the problem

$$\begin{cases} u_t = (|u_x|^{p-2}u_x)_x + |u|^{q-2}u, & (x,t) \in (-L,L) \times (0,T), \\ u(-L,t) = u(L,t) = 0, & t \in [0,T), \\ u(x,0) = \varphi(x) > 0, & x \in (-L,L), \end{cases}$$

where $p > 2$, $q > 2$ and $L > 0$ are parameters.

We describe in terms of p, q and L when solutions of a semidiscretization in space exist globally in time and when they blow up in a finite time. The critical blow-up exponent, as in the continuous case, turns out to be $q = p$; that is, every numerical solution is global if $q > p$, whereas for $q > p$ and $q = p$, the existence of blowing-up solutions is showed in terms of the size of the initial datum and the parameter L, respectively.

The convergence of the numerical scheme, as well as the convergence of the blow-up time are proven.

We also find the blow-up rates and the blow-up sets by means of the discrete self-similar profiles.

A Perron type theorem for functional differential equations

by *Mihály Pituk*

A Perron type theorem about the existence of the strict Lyapunov exponents of the solutions of retarded functional differential equations is presented. Asymptotic relations between the solutions of a linear autonomous equation and the solutions of the corresponding perturbed equation are given. It is shown that in the scalar case the existence of a positive solution of the perturbed equation often implies the existence of a real eigenvalue of the limiting equation.

On a new approximation scheme for the steady compressible Navier–Stokes equations

by *P. B. Mucha and M. Pokorný*

We consider the steady compressible Navier–Stokes equations in the barotropic regime. For the situations when it possible to show boundedness of the density up to the boundary, as e.g. for the two-dimensional case with slip boundary conditions, we present a new approximation scheme. The existence of a solution as well as its certain regularity can be shown in a quite simple way.

Asymptotic symmetry of positive solutions of parabolic equations: bounded domains reconsidered

by *Peter Poláčik*

We consider fully nonlinear parabolic equations on nonsmooth bounded domains under Dirichlet boundary condition. Assuming that the equation and the domain satisfy certain reflectional-symmetry assumption, we establish the asymptotic symmetry of bounded positive solutions. Compared with earlier theorems of this kind, we do not assume certain crucial assumptions, such as regularity of the nonlinearity in time. Our method relies on new techniques, inspired by a study of similar problems on unbounded domains, and gives in some sense optimal results.

Evans functions and blow-up for degenerate shock waves

by *Nikola Popovic*

We consider the Evans function approach to the stability of viscous shock waves in the case of characteristic shocks, i.e. shocks with shock speed equal to a characteristic speed at one of the end states. In comparison to the well-understood non-characteristic case two complications arise: first, the slow (merely algebraic) decay of the traveling wave at the characteristic end state; second, the fact that the essential spectrum of the corresponding linearized equation has a branch point at the origin. We show how an Evans function can still be meaningfully defined in that case by means of the blow-up technique.

Optimal control of Navier–Stokes equations by Oseen approximation

by *Miroslav Pošta*

A non-standard sequential-quadratic-programming-type iterational process based on Oseen's approximation is proposed for an optimal control problem for the steady-state Navier–Stokes equations. Further numerical approximation by a finite-element method and sample computational experiments are presented, too.

Dynamics near attractive integral manifolds under discretization

by *Christian Pötzsche*

In this talk, we consider a class of nonautonomous difference equations possessing an attractive invariant manifold in the extended state space. It is our aim to study the behavior of this manifold, as well as of the corresponding invariant foliations and the asymptotic phase under perturbation. Such perturbations, e.g., occur under numerical time discretization of nonautonomous evolutionary equations.

Our framework is sufficiently general to include (center-)unstable or inertial manifolds. We obtain results concerning the C^k-closeness of the invariant manifolds and foliations. Moreover, the rate of convergence will be estimated.

A remark on characterization of entropy solutions using Colombeau's algebra of generalized functions

by *Dalibor Pražák*

Colombeau's algebra of generalized functions is used to study the solutions to a single hyperbolic conservation law. In a simple setting of travelling shocks, we formulate a new interesting necessary and sufficient condition for the solution to be entropic.

Liouville type theorems for superlinear parabolic equations and applications

by *Pavol Quittner*

We present new nonexistence results concerning positive entire solutions of parabolic equations with superlinear nonlinearities. Such results play a crucial role in the study of the asymptotic behavior of solutions of related equations in both bounded and unbounded domains (decay of global solutions, completeness of blow-up etc.).

Some aspects of an Aubry–Mather theory for PDE's

by *Paul Rabinowitz*

For a class of PDE's initially studied by Moser and by Bangert, we describe how minimization and constrained minimization arguments can be used to find a symbolic dynamics of heteroclinic and homoclinic solutions.

Equations with inverse Preisach operator

by *Dmitrii Rachinskii*

We consider differential equations that contain a highest order time derivative of the Preisach hysteresis nonlinearity and equivalent systems with the inverse Preisach operator. Well-posedness of the systems and periodic solutions are studied.

On the structure of the set of bifurcation points of periodic solutions for multiparameter Hamiltonian systems

by *Wiktor Radzki*

Consider the autonomous Hamilton equation

$$\dot{x}(t) = J\nabla_x H(x(t), \lambda),$$

where $H \in C^2(\mathbb{R}^{2n} \times \mathbb{R}^k, \mathbb{R})$, and assume that $\nabla_x H(x_0, \lambda) = 0$ for some $x_0 \in \mathbb{R}^k$ and every $\lambda \in \mathbb{R}^k$. Our aim is to give a local description of the set of (global) bifurcation points of 2π-periodic solutions of this equation in a neighbourhood of the point (x_0, λ_0) for given $\lambda_0 \in \mathbb{R}^k$.

We restrict our discussion to the case of the systems satisfying, for every $\lambda \in \mathbb{R}^k$, the condition $\nabla_x^2 H(x_0, \lambda) = \begin{bmatrix} A(\lambda) & 0 \\ 0 & B(\lambda) \end{bmatrix}$, where $A(\lambda)$ and $B(\lambda)$ are some $(n \times n)$-matrices. The Hessian $\nabla_x^2 H(x_0, \lambda_0)$ can be singular. However, we assume that the local Brouwer degree of $\nabla_x H(\cdot, \lambda_0)$ at x_0 is nonzero.

The bifurcation points of solutions with periods $\frac{2\pi}{j}$, $j \in \mathbb{N}$, can be identified with zeros of the functions $F_j : \mathbb{R}^k \to \mathbb{R}$ defined as $F_j(\lambda) = \det[A(\lambda)B(\lambda) - j^2 I]$, provided that λ_0 is an isolated singular point of F_j (the proof is based on Dancer and Rybicki theorem). Consequently, for analytic F_j the set of bifurcation points can be locally described by using methods of real algebraic geometry.

Inverse problem in celestial mechanics

by *Rafael O. Ramirez and Natalia Sadovskaia*

We study the inverse problem in Celestial Mechanic of constructing the potential-energy function U capable of generating the $N-1$ parametric family of orbits for a mechanical system with N degree of freedom. We propose a new approach to solve the inverse Suslov problem and a generalization of the Joukovski problem.

The problem of constructing the potential function capable to generate the bi-parametric family of orbits for a particle in space is solved. We deduced the system of two lineal partial differential equations with respect to function U, which contain as a particular case the Szebely equation. We give a detailed solutions for the inverse Bertrand problem on the constructing the potential-energy function capable of generating the family of conics . We establish the relation between this problem and the solution of the Heun equations with singularities at the points

$$0, 1, \frac{1+b}{2b}, \infty$$

and with exponents

$$(0, \frac{j+3+b(j+1)}{2b});\ (0, j-\frac{j+3+b(j+1)}{2b});\ (0, j+1); (-1-j, 1-j), \quad j \in \mathbb{Z}$$

where b is the eccentricity of the conics.

A partial extension of the Courant nodal domain theorem to the p-Laplacian

by *Humberto Ramos Quoirin*

This communication deals with a nodal domain property related to the problem

$$\begin{cases} -\Delta_p u = \alpha m(x)(u^+)^{p-1} - \beta n(x)(u^-)^{p-1} & \text{in} \quad \Omega \\ u = 0 & \text{on} \quad \partial\Omega \end{cases} \tag{1}$$

where $\Omega \subset \mathbb{R}^N$ is a bounded domain and m, n are weight functions which can change sign. Our main result states that when m, n are bounded and (α, β) is in the first nontrivial curve of the Fučik spectrum, the solutions of (1) have exactly two nodal domains. This result, proved for $m \equiv n \equiv 1$ by Cuesta-DeFigueiredo-Gossez and Drabek-Robinson, is a partial extension of the Courant nodal domain theorem related to the Laplacian. The boundedness of m, n is required in order to have enough regularity for the solutions of (1) and to apply the Hopf maximum principle of Vazquez.

Asymptotic analysis of a nonlinear partial differential equation in a semicylinder

by *Peter Rand*

Small solutions of a nonlinear partial differential equation in a semi-infinite cylinder will be studied. We consider the asymptotic behaviour of these solutions at infinity under Neumann boundary condition as well as Dirichlet boundary condition. In the Neumann case it can be shown that any solution small enough either vanishes at infinity or tends to a nonzero periodic solution of a nonlinear ordinary differential equation. In the Dirichlet case every solution small enough vanishes.

New Rosenbrock methods of order 3 for PDAEs of Index 2

by *Joachim Rang*

In this talk new Rosenbrock methods for index 2 PDAEs are presented. These solvers are of order 3, have 4 internal stages, and satisfy certain order conditions to improve the convergence properties if inexact Jacobians and approximations of $\frac{\partial f}{\partial t}$ are used. A comparison with other Rosenbrock solvers shows the advantages of the new methods.

Morse decompositions of nonautonomous dynamical systems

by *Martin Rasmussen*

The global asymptotic behavior of dynamical systems on compact metric spaces can be described via Morse decompositions. Their components, the so-called Morse sets, are obtained as intersections of attractors and repellers. In this talk, we introduce special notions of attractor and repeller for nonautonomous dynamical systems which are designed to establish nonautonomous generalizations of the Morse decomposition. We discuss the dynamical properties of these Morse decompositions and consider Morse decompositions of one-dimensional and linear systems.

Perturbed Navier–Stokes equations

by *Geneviève Raugel*

In this talk, we consider a singular perturbation of the Navier–Stokes equations in space dimension two, depending on a small parameter ϵ. We prove global existence and uniqueness of solutions for bounded relatively large initial data. We also study the convergence of the solutions to those of the limiting Navier–Stokes equations, when the parameter ϵ goes to zero.

Nonlinear boundary stabilization of the Schrödinger equation with variable coefficients

by *Salah-Eddine Rebiai*

Energy decay rates are obtained for the solutions of the Schrödinger equation with variable coefficients in the principal part subject to nonlinear dissipative feedback acting in the Neumann boundary condition.

Local existence and uniqueness for quasilinear parabolic initial boundary value problems with non-smooth data

by *Lutz Recke*

This talk concerns initial boundary value problems for quasilinear divergence type second order parabolic equations and systems with non-smooth data. Here "non-smooth data" means that the domain can be non-smooth (but Lipschitz), that the boundary conditions can change type (mixed boundary conditions, where the "Dirichlet" and the "Neumann" boundary parts can touch) and that the coefficients of the equations and the boundary conditions can be discontinuous with respect to the space variable (but they have to be smooth with respect to the unknown function u and linear with respect to its gradient ∇u).

The aim is to prove existence and uniqueness of a local weak solution u and to show that u and its time derivative $\partial_t u$ are Hölder continuous. For that we use the Implicit Function Theorem as well as a maximal regularity result of J. A. GRIEPENTROG for corresponding linear problems in parabolic Sobolev Campanato spaces.

Convergence in evolutionary variational inequalities with hysteresis nonlinearities

by *Volker Reitmann and Holger Kantz*

We consider the evolutionary variational inequality

$$(\dot{y} - Ay - B\xi(t), \eta - y)_{-1,1} + \psi(\eta) - \psi(y) \geq 0\,,\ \forall \eta \in Y_1\,, \text{a.a. } t \in \mathbb{R}_+\,, \qquad (1)$$

$$w(t) = Cy(t)\,, \quad \xi(t) = \varphi[w, \xi_0](t). \qquad (2)$$

It is assumed that $A \in \mathcal{L}(Y_0, Y_{-1})$, $B \in \mathcal{L}(\Xi, Y_{-1})$ and $C \in \mathcal{L}(Y_{-1}, W)$, where Ξ, W are Hilbert spaces and $Y_1 \subset Y_0 \subset Y_{-1}$ is a real rigged Hilbert space structure. The symbol $(\cdot,\cdot)_{-1,1}$ denotes the "scalar product" in $Y_{-1} \times Y_1, \psi \in L^1(Y_1, \mathbb{R}_+)$ is a lower semicontinuous and convex function, and φ is a rate-independent hysteresis operator which generates positive path integrals. Using the solvability of operator Riccati equations by the Yakubovich-Likhtarnikov theorem, we derive frequency-domain conditions for the convergence of an arbitrary solution of (1), (2) for $t \to +\infty$ to the stationary set. As an example we consider a second-order evolutionary variational inequality with a constitutive law defined as sum of a linear viscosity term and a hysteresis-type elasto-plastic term.

Dissipative dynamics of reaction diffusion equations in R^N

by *J. M. Arrieta and A. Rodríguez-Bernal*

In this talk we present some recent results about the dissipative behavior of large classes of reaction diffusion equations in R^N. We show that in large spaces of initial data, not having any decay at infinity, these equations define asymptotically compact semigroups and have a compact global attractor.

The classes of equations considered include some type of logistic–like equations which may have travelling wave solutions.

Under some additional conditions we also show that the attractors have finite Hausdorff and fractal dimensions.

Asymptotic behaviour of travelling waves in a bistable reaction diffusion equation with respect to non-integrable perturbations.

by *Violaine Roussier-Michon*

We consider the following reaction-diffusion equation

$$\partial_t u = \Delta u + f(u), \quad x \in R^d \quad t > 0 \tag{1}$$

where f is a bistable non-linearity and $d \geq 2$. We know that there exist some particular solutions $u(x,t) = w_0(x \cdot k - ct)$ called planar travelling waves and we study their asymptotic stability with respect to non-integrable perturbations. Let us note $u(x,t)$ some solutions of (1) closed to w_0 at time $t = 0$. We prove that if $u_0 \in C^{2+\alpha}(R^d)$ then this solution exists for all time in $C^{1+\alpha/2,2+\alpha}(R^+ \times R^d)$ and satisfies the following estimates

$$\lim_{t \to +\infty} t \| u(x,t) - w_0(x \cdot k - ct)\|_{C^{1+\alpha/2,2+\alpha}} = 0$$

The proof uses a spectral decomposition of u and some parabolic estimates due to Ladyzenskaja. Some similar results have been already obtained by Kapitula in 1997 for integrable perturbations in $H^k(R^d)$ which enable some energy estimates that we cannot use here. Finally, thoses results are at present extended to conical fronts in bistable reaction-diffusion equations. This work is done in association with J.M. Roquejoffre.

Bound states of nonlinear Schrödinger equations with potentials vanishing at infinity

by *A. Ambrosetti, A. Malchiodi and D. Ruiz*

We consider semiclassical states for the nonlinear Schrödinger equation:

$$-\varepsilon^2 \Delta u + V(x) u = u^p, \quad x \in \mathbb{R}^n, \quad u > 0.$$

where $1 < p < \frac{n+2}{n-2}$ and $V(x)$ a positive potential, $V(x) \sim |x|^{-\alpha}(|x| \to +\infty)$ for $0 \leq \alpha \leq 2$. We show that for ε small, there exists finite energy solutions concentrating around some point x_0, provided that x_0 is a stable stationary point of $V(x)$. The limit exponent $\alpha = 2$ seems to be a limiting exponent in order to find solutions with finite energy. The proofs use a perturbation technique in a variational setting, through a Lyapunov–Schmidt reduction.

Variational problems in image and surface matching

by *Martin Rumpf*

Variational methods for the matching of uni-modal and multi-modal images via continuous, non rigid deformations are presented. In the uni-modal case we emphasize analytical and numerical problems arising for the matching of images with sharp edges. Furthermore, we consider the simultaneous segmentation and morphological matching of images. This approach is based on a joint Mumford Shaw type segmentation for the singular part of the morphology and a variational formulation for the defect of the regular morphology consisting of the Gauss maps of the images.

In case of surface matching, we apply well established matching methods from image processing in the parameter domains. A matching energy is considered which depends on curvature, feature demarcations or surface textures. The metric on both surfaces is properly incorporated into the formulation of the energy.

Periodic solutions of Hamiltonian system in a neighborhood of a degenerate rest point

by *Sławomir Rybicki*

$$\dot{x}(t) = J\nabla H(x(t)), \tag{1}$$

where $H \in C^2(\mathrm{R}^{2\mathrm{N}}, \mathrm{R})$. Assume that

- $\nabla H(x_0) = 0,$
- x_0 is isolated in $(\nabla H)^{-1}(0)$.

The aim of my talk is to formulate sufficient conditions for the existence of connected families of non-stationary periodic solutions of system (1) emanating from the stationary solution $x_0 \in \mathrm{R}^{2\mathrm{N}}$. The assumptions will be formulated in terms of the Brouwer degree of ∇H computed on a small disc centered at x_0 and the eigenvalues of $\nabla^2 H(x_0)$.

The question of stability of facets of crystals growing from vapor

by *Piotr Rybka*

We survey our work with Yoshikazu Giga on a quasi-steady Stefan problem with the Gibbs-Thomson relation and a kinetic term. This set of equation is meant to model ice crystals growing from vapor. Our goal is to expose a number of properties of solutions to the system. The most important question for us is to show existence of a region in the phase space where the facets of the crystal remain stable, i.e. they don't break neither bend. We prove that there is a neighborhood of a unique equilibrium point, where the facets are indeed stable.

We also announce new results indicating what happens past the onset of instability. Rigorous analysis is presented in a simplified situation.

A uniform geostrophic flow affected by rotation: the Ekman boundary layer problem

by *Jürgen Saal*

The *Ekman boundary layer problem* is a famous problem in Meteorology. The task is to describe the motion of a rotating fluid (e.g. the atmosphere) inside a boundary layer, appearing between a uniform geostrophic flow (e.g. wind) and a solid boundary (e.g. the earth) at which the no slip condition applies.

Mathematically this situation is modeled by a Navier–Stokes equation with Coriolis force in a half-space. Remarkable persistent Stability of the *Ekman spiral*, which is an exact solution of this system, in atmospheric and oceanic boundary layers is noticed in geophysical literature (we refer e.g. to the spirals on satellite photos of the weather forecast). Since the Ekman spiral solution depends on the normal component only, it is natural to consider classes of initial data nondecreasing at infinity in tangential components. To deal with this fact is the main challenge in the analytical approach to the Ekman boundary layer problem, that we will present. This project is a joint work with Yoshikazu Giga, Katsuya Inui, Alex Mahalov, and Shin'ya Matsui.

Diffusion problems with bifurcation driven by the boundary conditions

by *José Sabina de Lis, Jorge García-Melián and Julio D. Rossi*

Several reaction-diffusion models, consisting in either scalar equations or systems, will be presented in order to show their bifurcation features when the key parameters are localized in the boundary conditions.

On Nehari solutions

by *Felix Sadyrbaev and Armands Gritsans*

We consider the Emden–Fowler equation $x'' = -q(t)|x|^{2\varepsilon}x, \quad \varepsilon > 0,$ which may have solutions of different types (for instance, oscillatory, non-oscillatory, singular (non-extendable), asymptotically linear ones). Nevertheless for a given interval $[a, b]$ and arbitrary integer $n > 0$ there exist solutions, which vanish at $t = a,\ t = b,$ have exactly $n - 1$ zeros in $(a, b).$ Among those solutions there is a solution, which minimizes the functional $\int_a^b x'^2(t)\,dt$ over solutions of the boundary value problem

$$x'' = -q(t)|x|^{2\varepsilon}x, \quad x(a) = x(b) = 0, \quad x(t) \text{ has } n-1 \text{ zeros in } (a, b),$$

where $q(t)$ is a positive valued continuous function. We call such solutions by Nehari solutions (Z. Nehari., Characteristic values associated with a class of nonlinear second-order differential equations, *Acta. Math.,* 1961. Vol. 105, n 3–4, pp. 141–175). In out talk we provide some new results about Nehari solutions and illustrate them with a comprehensive study of some specific equations.

Eigenvalues near the absolute spectrum of spiral waves

by *Björn Sandstede*

I will discuss spiral spectra: In particular, I will show how curvature terms affect these spectra by creating, on planar domains, infinitely many eigenvalues near branch-points of the linear dispersion relation. The analysis is carried out by reducing the relevant eigenvalue problems to the spectra of Schrödinger operators with complex potentials. This is joint work with Arnd Scheel.

Remarks on the incompressible Navier–Stokes flows for linearly growing initial data

by *Okihiro Sawada*

In this talk the existence of the unique locally-in-time smooth solutions to the Navier–Stokes equations in the whole space $\mathbb{R}^n$ is established, when the initial velocity U_0 grows linearly at space infinity. We mainly deal with $U_0(x) = Mx + u_0(x)$, where M is a constant matrix and u_0 is a function in $L^p(\mathbb{R}^n)$. Our key tool is the theory of Ornstein-Uhlenbeck semigroup. Moreover, if M is skew-symmetric, then the solutions are analytic in spatial variables. This research is a joint work with Matthias Hieber in TUD (Germany).

On the Stokes equation with Neumann boundary condition

by *Yoshihiro Shibata*

I will talk about the Stokes equation with Neumann boundary condition, which is obtained as a linearized equation of some free boundary problem for the Navier–Stokes equation. After giving the analytic semigroup approach to this problem, I will talk about so called L_p-L_q estimate of this analytic semigroup in an exterior domain and the maximal L_p regularity theorem for the non-homogeneous, right member, divergence condition and boundary condition in a bounded domain, which is applied to show some locally and globally in time existence of solutions to the free boundary problem of the Navier–Stokes equation.

On periodic and homoclinic orbits of a class of non-autonomous Hamiltonian systems

by *Leonard K. Shilgba*

We have proved some existence results for periodic and homoclinic solutions to a class of Hamiltonian systems with sign indefinite super-quadratic potential V in the C^2 class. However, without any uniform or local constraint on the modulus of the second derivative ΔV or on the growth of ∇V, some assumptions have been made which establish our results. We investigate existence of homoclinic solutions of the class of Hamiltonian systems

$$\begin{aligned} \ddot{u} - A(t)u + b(t)\nabla V(u) = 0 \\ u(\pm\infty) = \dot{u}(\pm\infty) = 0 \end{aligned} \qquad (P_H)$$

by introducing a unique condition that there exists $c_0 < T$ and $K \in C^0(\mathbb{R}, \mathbb{R}), K(0) > 0$ such that

$$\begin{aligned} &a) \quad (A'(0)u.u) \leq 0 \quad \text{for all} \quad u \in \mathbb{R}^N, |u| \leq c_0. \\ &b) \quad b'(0) < 0. \\ &c) \quad \frac{1}{2}(A'(t)u.u) - b'(t)V(u) \geq K(t), t \in (-c_0, c_0), |u| \leq c_0. \end{aligned}$$

which helps us avoid imposing stringent conditions on ΔV.

Higher order quasilinear parabolic equations with singular initial data

by *Andrey E. Shishkov*

Well known result of H. Bresis, A. Fiedman says that the Cauchy problem for heat equation with nonlinear absorption:

$$\begin{aligned} &u_t - \Delta u + |u|^{p-1}u = 0 \quad \text{in } Q = \mathbb{R}^N \times \mathbb{R}_+ \\ &u(0,x) = \delta(x) \quad \text{in } \mathbb{R}^N \quad (\delta(x) \text{ – Dirac measure}) \end{aligned}$$

has solution for any $p < p_0 := 1 + \frac{2}{N}$ (Fujita exponent), and does not have solution for any $p \geq p_0$. We propose approach based on some local integral a priori estimates, which allow to study singular solutions of general parabolic equations of the form:

$$\left(|u|^{r-1}u\right)_t + \sum_{|\alpha|=m} (-1)^m D_x^\alpha a(t,x,u,\dots,D^m u) + g(t,x,u) = 0, \tag{1}$$

where $r > 0,\ m \geq 1$ and natural conditions hold:

$$\begin{aligned} &\sum_{|\alpha|=m} a_\alpha(x,t,\xi)\xi_m^{(\alpha)} \geq d_1 \Bigg(\sum_{|\beta|=m} \left|\xi_m^{(\beta)}\right| \Bigg)^{q+1}, \quad d_1 > 0,\ q > 0, \\ &\left|a_\alpha(x,t,\xi_0,\xi_1,\dots,\xi_m)\right| \leq d_2 \Bigg(\sum_{|\beta|=m} \left|\xi_m^{(\beta)}\right| \Bigg)^{q} \quad d_2 > 0, \\ &|g(x,t,s)| \leq d_3|s|^p, \quad g(x,t,s)s \geq d_4|s|^{p+1}\ \forall\, s \in \mathbb{R}^1,\ d_4 > 0. \end{aligned}$$

Particulary the following general statement is true.

Th 1 *Let* $r = p,\ p > \tilde{p}_0 := q + \dfrac{q(q+1)m}{N}$*, let* $u(x,t)$ *be arbitrary generalized solution of equation* (1) *satisfying in weak sense condition:* $u(0,x) = 0\ \forall\, x \neq 0$*. Then* $u(0,x) = 0\ \forall\, x \in \mathbb{R}^N$ *and moreover* $u \equiv 0$ *if* $p > q + \dfrac{m(q+1)^2}{N}$.

It means that for $p > \tilde{p}_0$ equation (1) does not have source-type solution and moreover any very singular solution.

Propagation of support in multidimensional higher order degenerate diffusion-convection equation

by *Andrey E. Shishkov*

We consider Cauchy problem for a class of degenerate quasilinear parabolic equation with model representative:

$$(|u|^{q-1}u)_t + (-1)^m \sum_{|\alpha|=m} D_x^\alpha\big(|D_x^m u|^{p-1} D_x^\alpha u\big) + \sum_{i=1}^n \chi_i (|u|^{\lambda-1}u)_{x_i} = 0, \quad (x,t) \in \mathbb{R}^n \times (0,T),$$

$$u(0,x) = u_0(x) \in L_{q+1,loc}(\mathbb{R}^n), \quad p > q > 0,\ \lambda > 0,\ \overrightarrow{\chi} \in \mathbb{R}^n,\ n \geq 1,\ m \geq 1,$$

where supp $u_0(x) \neq \mathbb{R}^n$. We find conditions which guarantee finite speed propagation of support of arbitrary generalized energy solution and obtain sharp upper estimates of this propagation in dependence of direction of convection (“slowly” and “fast” interface). We investigate starting behaviour of interfaces in dependence of local behaviour of $u_0(x)$ in the neighborhood of the boundary of its support. We describe evolution of support for $t \to \infty$ in dependence of global properties of $u_0(x)$ and direction $\overrightarrow{\chi}$ of convection.

Elliptic equations with nonhomogeneous nonlinearity: existence and localization properties of solutions

by *Stanislav Antontsev and Sergey Shmarev*

We study the Dirichlet problem for the nonlinear elliptic equations with nonhomogeneous anisotropic nonlinearity

$$\sum_i D_i\Big(a_i(x,u,D_iu)D_iu\Big) + c(x,u)\,u = f(x) \quad \text{in } \Omega,$$

where Ω is a domain in $\mathbf{R}^n$ (not necessarily bounded). It is assumed that either $a_i = a_i(x,u)|D_iu|^{p_i(x)-2}$ or $a_i(x,u)|u|^{\gamma_i(x)}$, and $c(x,u) = c(x)\,|u|^{\sigma(x)-2}$ with the exponents of nonlinearity $p_i(x)$, $\sigma(x)$, $\gamma_i(x) \in (1,\infty)$, where $a_i(x,u) \geq a_0 > 0$ and $c(x) \geq c_0 \geq 0$. We prove solvability of this problem and derive the conditions on the character of nonlinearity and the right-hand side f which guarantee localization of weak solutions (boundedness of $\operatorname{supp} u$ in Ω). It is shown that the localization effect can be caused by the anisotropy of the equation even in the absence of low-order terms. The study of localization properties is based on the application of the method of local energy estimates. The results are extended to weak solutions of systems of elliptic equations with similar type of nonlinearity.

Concepts of the Finite Element Toolbox ALBERTA

by *Kunibert G. Siebert*

During the last years, scientific computing has become an important research branch located between applied mathematics, applied sciences and engineering. Highly efficient numerical methods are based on adaptive methods, higher order discretizations, fast linear and non-linear iterative solvers, multi-level algorithms, etc. Such methods are integrated in the adaptive finite element software ALBERTA. It is a toolbox for the fast and flexible implementation of efficient software for real life applications, based on modern algorithms. ALBERTA also serves as an environment for improving existent, or developing new numerical methods in an interplay with mathematical analysis and it allows the direct integration of such new or improved methods in existing simulation software. In this talk we will present the main concepts of ALBERTA, latest developments, and applications.

This is joint work with Daniel Köster (Universität Augsburg) and Alfred Schmidt (Universität Bremen).

`http://www.alberta-fem.de/`

On non-uniformly parabolic functional differential equations

by *László Simon*

We shall consider weak solutions of initial-boundary value problems for the equation

$$D_t u - \sum_{i=1}^{n} D_i[a_i(t,x,u,Du;u)] + a_0(t,x,u,Du;u) = f$$

in $Q_T = (0,T) \times \Omega$, $\Omega \subset R^n$ where functions $a_i : Q_T \times R^{n+1} \times L^p(0,T;V) \to R$ (with a closed linear subspace V of the Sobolev space $W^{1,p}(\Omega)$, $p \geq 2$) satisfy certain generalization of Leray-Lions conditions such that

$$\sum_{i=0}^{n} a_i(t,x,\zeta_0,\zeta;v)\zeta_i \geq g_2(v)[|\zeta_0|^p + |\zeta|^p] - k_2(v)(t,x)$$

where the value of $g_2 : L^p(0,T;V) \to R^+$ may be arbitrary small positive number and $k_2 : L^p(0,T;V) \to L^1(Q_T)$ is a bounded operator.

Sufficient conditions are formulated on the existence and some properties of he solutions.

Evans function method for some combustion waves

by *Peter L. Simon*

The stability of a laminar flame supported by a combustion reaction system is considered using the Evans function method. The flame can be considered as a travelling wave solution of a reaction-diffusion system. The spectrum of the linearised second-order differential operator is investigated in detail. The special structure of the differential equations due to an Arrhenius temperature dependence is exploited. A simple geometrical method is shown for the study of the essential spectrum of the linearised operator, and for determining the domain of the Evans function. The results are applied to some representative combustion reactions, for which the Evans function is computed numerically and the stability of the flame is determined.

A priori estimates, monotonicity and Liouville theorems for nonvariational elliptic systems

by *Boyan Sirakov*

We study systems of the type

$$\begin{cases} -\Delta u_1 &= a(x)u_1^{\alpha_{11}} + b(x)u_2^{\alpha_{12}} + h_1(x, u_1, u_2) \\ -\Delta u_2 &= c(x)u_1^{\alpha_{21}} + d(x)u_2^{\alpha_{22}} + h_2(x, u_1, u_2), \end{cases}$$

Using a blow-up argument, we show that positive classical solutions of superlinear subcritical (a suitable notion is given) systems are uniformly bounded in the L^∞-norm. This is well-known to give existence results, via Leray-Schauder degree theory.

Implementing the blow-up method depends on showing nonexistence results the whole space or a half space. The latter is shown to depend on the former, via a monotonicity argument. This argument in turn relies on a Harnack inequality for systems.

This is a joint work with D. G. de Figueiredo from Campinas, Brazil.

Coarsening in thin-film equations: upper bound on coarsening rate

by *Dejan Slepčev*

Thin, nearly uniform layers of some fluids can destabilize under the effects of intermolecular forces. After the initial phase, the fluid breaks into droplets connected by an ultra-thin layer of fluid. This structure coarsens on a slow time scale. The characteristic distance between droplets and their size grow, while their number is decreasing.

This physical process can be modeled in the lubrication approximation by a thin-film equation for the height of the fluid. I will discuss coarsening in thin-film equations with mobility equal to the height of the fluid. These equations are gradient flows in the Wasserstein metric. Using the gradient flow structure within the Kohn–Otto framework we obtain rigorous upper bound on the coarsening rate. The upper bound we obtain coincides with the rate predicted by heuristic arguments and numerical computations.

This is joint work with Felix Otto and Tobias Rump.

On the noncontinuable solutions of retarded functional differential equations

by *Bernát Slezák*

Retarded functional differential equations are investigated, when the solutions have their values in a Banach space, from the point of view that under which assumptions and in what sense the noncontinuable solutions reach to the boundary of the domain of the function f on the right. In the finite dimensional case some results are obtained which are stronger than the classical ones.

Nonlinear elliptic systems and L^p_δ spaces.

by *Philippe Souplet*

We discuss recent results and techniques in the study of semilinear elliptic systems and equations. We are concerned with the questions of existence, regularity and a priori estimates of solutions of the Dirichlet problem. The techniques that we shall describe are based on properties of the weighted Lebesgue spaces $L^p_\delta(\Omega)$, where δ is the distance function to the boundary of the domain. (Part of this work is joint with Pavol Quittner.)

Gradient blow-up and global existence for viscous Hamilton-Jacobi equations

by *Philippe Souplet*

We consider the Dirichlet problem for the inhomogeneous Hamilton-Jacobi equation $u_t - \Delta u = |\nabla u|^p + h(x)$ with $p > 2$. For suitably large initial data, boundary gradient blow-up occurs in finite time. We study the relations between: (i) the existence of global classical solutions and (ii) the existence of stationary solutions (with gradient possibly singular on the boundary). We show that (i) implies (ii) and that in this case all global solutions converge uniformly to the (unique) stationary solution. In the radial case, we prove that, conversely, (ii) implies (i). We also discuss the existence of global classical solutions with gradient blowing up in infinite time, and universal bounds for global solutions. (Joint work with Qi S. Zhang.)

Eigenvalue questions on some quasilinear elliptic problems

by *M. N. Poulou and N. M. Stavrakakis*

We present resent results on some quasilinear elliptic problems of p-Laplacian type. Among other things we prove the existence of a positive principal eigenvalue for a p-Laplacian equation and discuss questions of simplicity and isolation of the eigenvalue. Further, we treat a degenerate p-Laplacian system where we get results on the existence of a continuum of positive solutions bifurcating from the principal eigenvalue.

Acknowledgments. This work was partially supported by a grant from from the `Pythagoras` Basic Research Program No. $68/831$ of the Ministry of Education, Hellenic Republic.

On some Klein–Gordon–Schrödinger type systems

by *Nikolaos M. Stavrakakis*

We present some recent trends in the theory of Klein-Gordon-Schrödinger type Systems. Then we give some resent results on the following special type of a dissipative Klein-Gordon-Schrödinger System

$$i\psi_t + \kappa\psi_{xx} + i\alpha\psi = \phi\psi,\ x \in \Omega,\ \ t > 0,$$
$$\phi_{tt} - \phi_{xx} + \phi + \lambda\phi_t = -Re\psi_x,\ x \in \Omega,\ \ t > 0,$$

satisfying the initial and boundary conditions

$$\psi(x,0) = \psi_0(x),\ \phi(x,0) = \phi_0(x),\ \phi_t(x,0) = \phi_1(x),\ x \in \Omega,$$
$$\psi(x,t) = \phi(x,t) = 0,\ x \in \partial\Omega,\ t > 0,$$

with $\kappa,\ \alpha,\ \lambda$ positive constants and Ω a bounded subset of $\mathbb{R}$. This certain system describes the nonlinear interaction between high frequency electron waves and low frequency ion plasma waves in a homogeneous magnetic field. Global existence and uniqueness of solutions are derived. Also necessary conditions for the exponential energy decay of the system are established. Finally, we present some first results on the numerical treatment of the above system.

Acknowledgments. This work was partially supported by a grant from the *Pythagoras* Basic Research Program No. $68/831$ of the Ministry of Education of the Hellenic Republic.

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Sweeping processes with monotonicity

by *Ulisse Stefanelli*

I shall survey some old and recent results on the possibility of solving so-called quasivariational sweeping processes by means of order methods. The latter possibility occurs in presence of some suitable monotonicity structure of the problems and is somehow strictly related to the validity of abstract comparison principles. I will give some concrete examples of quasivariational evolution problems fitting this monotonicity framework and sketch the main ideas for an existence proof.

On discrete boundary value problems

by *Petr Stehlík*

Discrete problems have attracted recently a lot of attention, especially with the evolution of the time scale calculus. The majority of results is obtained, naturally, via generalisations of continuous counterparts. We present two examples (discrete periodic BVP and BVP for discrete inclusions) which prove that we can obtain similar or better results by looking for other ways. Our tools include fixed-point theorems and variational methods.

Positive solutions of p-type retarded functional linear differential equations

by *Zdeněk Svoboda*

An existence of positive solutions on an interval of the form $[t_0, \infty)$ is studied for systems of retarded functional linear differential equations with unbounded delay and with finite memory. For this type of retarded functional differential equations a procedure using the special function p is known.

The general criterion in the form of sufficient and necessary conditions of existence of positive solutions of some class of retarded functional linear equations is given. Moreover, the sufficient condition for more general class of these equations is shown. The corresponding applications to scalar equations with several discrete delay are studied. The results for systems of linear equations with delay are mentioned too.The examples are inserted to illustrate these results.

Blow-up analysis of delayed Hopf-Bifurcations

by *Peter Szmolyan*

Differential equations with slowly varying parameters can behave quite differently from the corresponding static bifurcation problems. In the case of Hopf bifurcations the well known phenomenon of bifurcation delay occurs in analytic systems. We give a geometric analysis of this phenomenon. The analysis is based on the choice of a suitable integration path in complex time and the blow-up method for singularly perturbed differential equations.

Oscillation almost everywhere

by *Jacek Tabor*

Let T be a strongly continuous semigroup with generator A in a Banach space X. We say that a point $x \in X$ oscillates if the function $\mathbf{R}_+ \ni t \to \xi(T(t)x)$ oscillates (changes sign) for every linear functional $\xi \in X^*$.

Roughly speaking, one of the main known results concerning oscillation is the following

Theorem. Under some additional assumptions, every point $x \in X$ oscillates iff $\sigma(A) \cap \mathbf{R} = \emptyset$.

The aim of my talk is to discuss what happens when the above condition fails to hold, that is when $\sigma(A) \cap \mathbf{R} \neq \emptyset$. Of course, under no additional assumption nothing can be proved. We have to assume that the ”oscillation factor” in the spectrum of A is somehow stronger then the behaviour of T. The right condition is

$$\sup\{\sigma(A) \cap \mathbf{R}\} < \sup\{\mathrm{re}(\sigma(A))\}.$$

It occurs that the above assumption guarantees oscillation (in a weaker sense) of almost all points in X.

The above result can be in particular applied to oscillation of solutions of linear delay differential equations.

Existence of solutions with prescribed numbers of zeros of two-point boundary value problems for the one-dimensional p-Laplacian

by *Satoshi Tanaka*

This talk is a joint work with Yūki Naito.

Consider the two-point boundary value problem

$$(1)\qquad \begin{cases} (|u'|^{p-2}u')' + a(x)f(u) = 0, & 0 < x < 1, \\ u(0) = u(1) = 0, \end{cases}$$

where $p > 1$, $a \in C^1[0,1]$, $a(x) > 0$ for $0 \le x \le 1$, $f \in C(\mathbf{R})$, $f(s) > 0$ for $s > 0$, $f(-s) = -f(s)$ for $s > 0$ and f is locally Lipschitz continuous on $(0,\infty)$. Assume moreover that there exist limits f_0 and f_∞ such that $0 \le f_0, f_\infty \le \infty$,

$$f_0 = \lim_{s\to+0} \frac{f(s)}{s^{p-1}} \quad \text{and} \quad f_\infty = \lim_{s\to\infty} \frac{f(s)}{s^{p-1}}.$$

Let λ_k be the k-th eigenvalue of

$$\begin{cases} (|\varphi'|^{p-2}\varphi')' + \lambda a(x)|\varphi|^{p-2}\varphi = 0, & 0 < x < 1, \\ \varphi(0) = \varphi(1) = 0. \end{cases}$$

Theorem 1. *Assume that either $f_0 < \lambda_k < f_\infty$ or $f_\infty < \lambda_k < f_0$ for some $k \in \mathbf{N}$. Then problem* (1) *has a solution u_k, which has exactly $k-1$ zeros in $(0,1)$ and satisfies $u_k'(0) > 0$.*

On oscillation of higher order nonlinear differential equations

by *Tomoyuki Tanigawa*

The even-order nonlinear

$$(\text{A})\qquad (|x^{(n)}|^{\alpha-1}x^{(n)})^{(n)} + q(t)|x|^{\beta-1}x = 0,$$

is considered under the hypotheses that α and β are positive constants and $q(t)$ is a positive continuous function on $[a,\infty)$, $a > 0$. It is shown that a necessary and sufficient condition for oscillation of all solutions of (A) can be established provided α and β are distinct.

On the stability of solutions for a mathematical model of PDEs arising in chemotaxis

by *J. Ignacio Tello*

Chemotaxis is the phenomenon whereby living organisms respond to chemical substance by motion and rearrangement (taxis). They may move toward the higher concentration of the chemical substance (positive taxis), or away from it (negative taxis). A first mathematical model of chemotaxis, modelling the aggregation of certain types of bacteria, was presented by Keller and Segel (J. Theoret. Biol. 26 (1970) pp. 399–415).

The model we study involves a density distribution u of a population and the chemical concentration v in a system of partial differential equations,

$$\frac{\partial}{\partial t}u = \Delta u - \text{ div } (u\chi(v)\nabla v) + g(u,v),$$

$$\frac{\partial}{\partial t}v = \epsilon\Delta v + h(u,v).$$

We will study the stability of steady states under suitable assumptions in the data ϵ, χ, g and h.

Saddle point theorem and Fredholm alternative

by *Petr Tomiczek*

Let the operator $A : H \to H$ be a linear, compact, symmetric and positive on the separable Hilbert space H. In this paper we prove that the Fredholm alternative for such operator A is a consequence of the Saddle Point Theorem and Main Theorem of Quadratic Variational Problems.

The support re-splitting phenomemna caused by the interaction between diffusion and absorption

by *Kenji Tomoeda*

Numerical experiments suggest the interesting properties in the several fields. One of them is the occurrence of *support re-splitting phenomena* caused by the interaction between diffusion and absorption, where support splitting phenomena means that the region occupied by the flow becomes disconnected. From only numerical computations it is difficult to justify whether such phenomena are true or not, because the space mesh and the time step are sufficiently small but not zero. So the mathematical analysis is needed.

In this talk such phenomena are investigated by use of finite difference scheme, and justified from numerical and analytical points of view. The interface equation, the comparison theorem and the nonincrease of the number of local maximum points for the solution are used.

Oscillation of a class of superlinear neutral difference equations of higher order

by *A. K. Tripathy*

Sufficient conditions are obtained under which all solutions of

$$\Delta^m [y(n) + p(n)y(n-\tau)] + q(n)G(y(n-\sigma)) = 0,\ n \geq 0 \qquad (H)$$

oscillate, which is the discrete analogue of

$$[y(t) + p(t)y(t-\alpha)]^{(n)} + q(t)G(y(t-\beta)) = 0,\ t \geq 0$$

Here an attempt is made to study the oscillatory behaviour of (H), when G is superlinear satisfying $xG(x) > 0$, $x \neq 0$, $G \in C(R, R)$ and $p(n)$ lies in different ranges with odd or even m.

Validity of amplitude equations for electro-convection in nematic liquid crystals

by *Hannes Uecker*

Electro-convection in nematic liquid crystals is the paradigm for pattern formation in anisotropic systems. The Ginzburg–Landau equation is widely used to describe the system close to the first instability. Here we prove error estimates showing the validity of this formal approximation for a regularized weak electrolyte model (WEM). The difficulties are due the complexity of the WEM and due to the time-periodic forcing.

Joint work with Norbert Breindl and Guido Schneider.

On blow up at space infinity for semilinear heat equations

by *Yoshikazu Giga and Noriaki Umeda*

A nonnegative blowing up solution of the semilinear heat equation $u_t = \Delta u + f(u)$ is considered when initial data u_0 satisfies

$$\lim_{|x|\to\infty} u_0 = M > 0, \quad u_0 \leq M \quad \text{and} \quad u_0 \not\equiv M$$

and nonlinear term f satisfies $f(u) > 0$, $f'(u) > 0$ for $u > 0$, $\int_1^\infty ds/f(s) < \infty$ and some condition. It is shown that the solution blows up only at space infinity and that $\lim_{|x|\to\infty} u(x,t)$ is the solution of the ordinary differential equation $v_t = f(v)$ with $v(0) = M$.

FLENS - A Flexible Library for Efficient Numerical Solutions

by *Karsten Urban*

The goal of FLENS is have an efficient and flexible numerical toolbox that can be used both in teaching and research. This goal of course poses several demands that have guided us to several design principles.

The main focus of application are adaptive numerical methods (mainly wavelet methods) for PDEs. To this end, we need data structures and algorithms for infinite-dimensional sequences and fast access to single entires of these sequences.

In this talk, we explain the main design principles and show some realization. Also industrial applications are shown.

On a numerical model of phase transformation in substitutional alloys

by *Jiří Vala*

A new model for the diffusive phase transformation with a finite number r of substitutional components is based on the application of the Onsager's thermodynamic extremal principle; it assumes the migrating interface of finite thickness with finite mobility and solute segregation and drag in the interface. The mathematical analysis leads to a system of PDEs of evolution of the first order (driven by chemical potentials of particular components) for unknown molar fractions $c_1, \ldots, c_r$; nonlinear coefficients of such PDEs include (as an additional variable) an interface displacement rate $v(c_1, \ldots, c_r)$, evaluated from a nonlocal algebraic equation.

Especially in the one-dimensional stationary case (where v is independent of time) such system degenerates to a system od ODEs; in this case reliable material characteristics at least for a Fe-rich Fe-Cr-Ni system ($r = 3$) from the Montainuniverität Leoben (Austria) are available. The software for transformation and differentiation of a large set of such characteristics (as complicated functions of c_1, c_2, c_3) makes use of MAPLE-supported symbolic manipulations. The simulation software has been written in MATLAB; some predicted results can be identified with those obtained by laboratory measurements and practical observations.

Degenerate subharmonic bifurcation in reversible systems

by *André Vanderbauwhede*

In autonomous time-reversible systems symmetric periodic orbits typically appear in one-parameter families; along such families simple multipliers can be locked on the unit circle, and when they pass a root of unity one sees under generic conditions two bifurcating branches of subharmonic periodic orbits, one stable, one unstable. These generic conditions are: (i) the simplicity of the multiplier (together with the non-existence of other resonant multipliers), and (ii) a transversality condition which requires that the root of unity is passed with non-zero speed (using an appropriate parametrization of the primary family). In this talk we will describe what happens when either one of these generic conditions is not satisfied, as can happen in one- or more parameter families of reversible systems. The main emphasis will be on case (ii) where so-called ”bananas” and ”banana-splits” appear. Such bananas can be found for example along the short period family of periodic orbits emanating from L4 (and L5) for a certain range of the mass ratio in the restricted 3-body problem; they play an important role in the bifurcations of the long period family as L4 passes through a sequence of resonances.

The work presented in this talk was done in collaboration with Maria-Cristina Ciocci (Imperial College), Francesco Javier Munoz Almaraz, Emilio Freire and Jorge Galan (University of Sevilla).

Capacitary estimates of solutions of semilinear parabolic equations

by *Laurent Véron*

We study the initial trace problem for positive solutions of

$$\partial_t u - \Delta u + u^q = 0$$

in $\mathbf{R}_+ \times \mathbf{R}^\mathbf{N}$ when $q > 1$. If in the subcritical case the lower and upper estimates are obtained easily with the help of the very singular solution, the situation is much more complicated in the supercritical case where a solution with an isolated singularity does not exist. The upper and lower estimates are obtained via Wiener type capacitary estimates. We present some implications of these estimates.

Extremal equilibria for parabolic non-linear reaction-diffusion equations

by *Aníbal Rodríguez-Bernal and Alejandro Vidal-López*

We prove the existence of two extremal equilibria for a wide class of parabolic reaction-diffusion equations (RD) whose non-linear term satisfies a suitable structure condition. Moreover, these equilibria are ordered. We also obtain some stability property for the extremal equilibria as well as uniform bounds for the asymptotic behaviour of the solutions in terms of the extremal equilibria. In fact, the attractor for (RD) is contained in the order interval defined by the extremal equilibria. The results can be extended in a natural way to non-autonomous equations with an analogous structure condition in the non-linear term. In this case, what it is obtained is the existence of two complete trajectory (which are ordered) bounding the asymptotic behaviour of the solutions in a pullback sense.

Optimal Lyapunov inequalities and applications to nonlinear problems

by *A. Cañada, J. A. Montero and S. Villegas*

This talk is devoted to the study of L_p Lyapunov-type inequalities ($1 \leq p \leq +\infty$) for linear partial differential equations. More precisely, we treat the case of Neumann boundary conditions on bounded and regular domains in R^N. It is proved that the relation between the quantities p and $N/2$ plays a crucial role. This fact shows a deep difference with respect to the ordinary case. The linear study is combined with Schauder fixed point theorem to provide new conditions about the existence and uniqueness of solutions for resonant nonlinear problems.

Heat equation with dynamical boundary conditions of reactive type

by *Enzo Vitillaro*

The aim of this talk is to give some recent results obtained in collaboration with Juan Luis Vazquez.

We study the initial boundary problem

$$\begin{cases} u_t - \Delta u = 0, & \text{in } Q = (0,\infty)\times\Omega; \\ u_t = k u_\nu, & \text{on } [0,\infty)\times\Gamma; \\ u(0,x) = u_0(x), & \text{on } \Omega, \end{cases}$$

where Ω is a bounded regular open domain in $\mathbb{R}^N$ $(N \geq 1)$, $\Gamma = \partial\Omega$, ν is the outward normal to Ω, and $k > 0$. In particular we prove that the problem is ill–posed when $N \geq 2$, while is well–posed in dimension $N = 1$. Moreover we carefully study the case when Ω is a ball in $\mathbb{R}^N$ in order to explain why the problem is ill–posed. As a byproduct we give several results on the elliptic eigenvalue problem

$$\begin{cases} -\Delta u = \lambda u, & \text{in } \Omega; \\ \Delta u = k u_\nu, & \text{on } \Gamma, \end{cases}$$

which can be easily re–written as a elliptic eigenvalue problem with eigen–parameter dependent boundary conditions.

Asymptotic analysis of elastic curved rods

by *Rostislav Vodák*

We suppose a convergent sequence of curved rods made from an isotropic elastic material and clamped on the lower basis or on both bases, and a linearized elasticity system posed on the sequence of the curved rods. We study the asymptotic behaviour of the stress tensor and the solution to this system, when the radius of the domains tends to zero and a body force has a special form. The curved rods with a nonsmooth line of centroids are covered by the used asymptotic method as well.

Conservation laws with flux with discontinuous coefficients: the question of uniqueness of solution

by *Julien Vovelle*

We discuss the uniqueness of entropy solutions for conservation laws as

$$u_t + (g(x,u))_x = 0 \qquad (1)$$

where the flux g is discontinuous with respect to x. Besides the question of determinacy for the evolution equation (1), the uniqueness of solution is related to the convergence of approximations, which we also discuss.

State-dependent delays, linearization, and periodic solutions

by *Hans-Otto Walther*

For differential equations with state-dependent delays the initial value problem (IVP) with data in open subsets of the familiar state spaces $C([-h,0],\mathbb{R}^n)$ or $C^1 = C^1([-h,0],\mathbb{R}^n)$ is in general not well-posed. Under mild conditions, however, there is a submanifold of C^1 on which the IVP generates a semiflow F with continuously differentiable solution operators $F(t,\cdot)$ and further smoothness properties. This yields local invariant manifolds at stationary points and a convenient Principle of Linearized Stability, among others. The ad-hoc technique of freezing the delay and then linearizing the resulting equation with time-invariant delay, which has been successfully used by several authors for results related to linearization, is explained within the new framework.

As applications a new Hopf bifurcation theorem, due to Markus Eichmann, and a global result about existence of stable hyperbolic periodic orbits are presented, the latter for a system describing position control by echo.

On domains with its indexes

by *Hwai-Chiuan Wang*

Let Ω be a domain in $\mathbb{R}^N$, $N \geq 1$, and $2^* = \infty$ if $N = 1,2$, $2^* = \frac{2N}{N-2}$ if $N > 2$, $2 < p < 2^*$. Consider the semilinear elliptic problem

$$-\Delta u + u = |u|^{p-2}u \quad \text{in } \Omega;$$
$$u \in H_0^1(\Omega).$$

Let $H_0^1(\Omega)$ be the Sobolev space in Ω. The existence, the nonexistence, and the multiplicity of positive solutions are affected by the geometry and the topology of the domain Ω. The characterization of domains in which this equation admits a positive solution is an important open question. In this article, we present various analyses and use them to characterize several categories of domains in which this equation admits a positive solution or multiple solutions.

Exact multiplicity of positive solutions of a p-Laplacian Dirichlet problem

by *Shin-Hwa Wang*

We study exact multiplicity of classical positive solutions u with $\|u\|_\infty \in (0,\infty)$ of the p-Laplacian Dirichlet problem

$$\begin{cases} (\varphi_p(u'(x)))' + \lambda f_q(u(x)) = 0, -1 \le x \le 1, \\ u(-1) = 0 = u(1), \end{cases} \tag{1}$$

where $\varphi_p(y) = |y|^{p-2} y$, $(\varphi_p(u'))'$ is the one-dimensional p-Laplacian, $\lambda > 0$ is a bifurcation parameter, and $f_q(u) = |1-u|^q$ is defined on $[0,\infty)$ with $q > 0$. More precisely, we give a classification of the bifurcation diagrams of classical positive solutions on the $(\lambda, \|u\|_\infty)$-plane. Hence we are able to determine the exact multiplicity of classical positive solutions.

The crystalline limit of the driven anisotropic Willmore flow: coarsening dynamics and scaling laws

by *Stephen J. Watson*

Quantum Dots are nano-scale faceted pyramidal structures that self-assemble from a planar semiconductor template. The discovery of these remarkable objects has provoked a renaissance in the theoretical study of faceted crystal surfaces. The associated mathematical models generally involve a partial differential equation (PDE) governing the crystalline surface, with possible couplings to adjacent bulk fields, such as a melt or a non-local elastic stress.

The driven anisotropic Willmore flow arises in precisely this context. I will present a theoretical characterization of the crystalline limit of this flow, as well as a detailed description its coarsening dynamics and associated scaling laws.

The singular limit of a reaction-diffusion system arising in solid combustion

by *Georg S. Weiss*

We present a result on the singular limit of the Self-propagating High-Temperature Synthesis system arising in solid combustion. As the activation energy tends to ∞, the SHS-system converges to the Stefan problem for supercooled water, i.e. the ill-posed Stefan problem. This has been predicted by B. Matkowsky–G. Sivashinsky almost 30 years ago.

This is a joint work with R. Monneau (CERMICS, Paris).

Optimal grow-up rate in a supercritical semilinear heat equation

by *Michael Winkler*

We study the grow-up rate of global unbounded positive solutions of the Cauchy problem in $\mathbf{R}^N$ for

$$u_t = \Delta u + u^p,$$

where $N \geq 11$ and $p > 1$ is a supercritical parameter. It is known that such solutions exist for initial data u_0 which satisfy $0 \leq \varphi(x) - u_0(x) \simeq |x|^{-l}$ as $|x| \to \infty$, where φ is an explicitly known singular steady state and l is sufficiently large. The purpose of the talk is to establish a connection between l and the optimal (algebraic) grow-up rate $\alpha(l)$ in $\|u(\cdot,t)\|_{L^\infty(\mathbf{R}^N)} \simeq t^{\alpha(l)}$. It turns out that

$$\alpha(l) \begin{cases} \text{is a linear function of } l & \text{for } l < l_0, \\ \text{is a constant} & \text{for } l > l_0. \end{cases}$$

$W^{2,p}$-estimates at the boundary for solutions of fully nonlinear, uniformly elliptic equations

by *Niki Winter*

We consider the Dirichlet Problem for $F(D^2u, Du, u, x) = f$ where F is measurable in x, continuous in the other variables, uniformly elliptic and satisfies some further structure conditions. The aim of this talk is to present a result on global $W^{2,p}$-estimates for viscosity solutions of the Dirichlet Problem.

First we follow an idea mentioned by Lihe Wang and prove $W^{2,p}$-estimates in B_1^+ for continuous F without dependence on Du, u. Using this result together with the interior estimates we get a result on $W^{2,p}$-strong solutions for the general F. Together with an existence theorem we get the desired result.

Second order Hardy type integral inequalities in different classes of functions

by *Katarzyna Wojteczek*

Integral inequalities are developing rapidly during last years. Second order integral inequalities $\int_I sh^2 dt \leq \int_I rh''^2 dt$, where weights r and s are functions of the variable t defined on the interval I which can be bounded or unbounded were considered by many authors using different approach to study them.

They were also obtained by Florkiewicz and Wojteczek by the uniform method of obtaining integral inequalities involving a function and its derivatives in two different classes of functions H and $\hat{H}$ satisfying some integral and boundary-type conditions. However these limit conditions are not easy to be verified. Now it will be shown how they can be transformed and simplified, in order to get inequalities for h and/or its derivative vanishing at the endpoints.

Interior regularity of weak solutions to the equations of motion of a class of non-Newtonian fluids

by *Jörg Wolf*

We consider weak solutions to the equations of stationary motion of a class of non-Newtonian fluids in $R^n\,(n = 2, n = 3)$ the constitutive law of which includes the "power law model" with ($q > \frac{2n}{n+2}$) as special case. We prove the existence of weak solution to these equations being Hölder continuous except on a closed set of measure zero.

Hidden lattice structures and oscillatory behavior of systems of polynomial ordinary differential equations

by *Sergei Yakovenko*

It is well known that a linear nth order differential equation with coefficients explicitly bounded on a finite segment, admit an explicit upper bound for the number of isolated zeros of any solution. A natural generalization of this fact for *systems* of first order linear equations fails. We will show how the upper bound can be constructed for systems of equations with *rational* coefficients, and explain following [Y04] the proof of A. Grigoriev's theorem [G01,G03], the strongest known result in this direction.

The proof is based, among other things, on the following geometric observation. If a real semialgebraic set in $\mathbf{R}^n$ is defined by *lattice polynomial equalities and inequalities*, then the diameter of this set is either infinite, or explicitly bounded above in terms of the magnitude of the polynomials.

The method can be generalized for arbitrary systems of polynomial first order differential equations.

[G01] A. Grigoriev, *Singular perturbations and zeros of Abelian integrals,* Ph. D. thesis, Weizmann Institute of Science (Rehovot), December 2001.

[G03] A. Grigoriev, *Uniform asymptotic bound on the number of zeros of Abelian integrals*, ArXiv preprint **math.DS/0305248** (2003).

[Y04] S. Yakovenko, *Oscillation of linear ordinary differential equations: on a theorem by A. Grigoriev*, ArXiv preprint **math.CA/0409198** (2004).

Some generalizations of the Lax-Milgram Theorem

by *Nikos Yannakakis*

We prove a linear and a nonlinear generalization of the Lax-Milgram theorem. In particular we give sufficient conditions for a real-valued function defined on the product of a reflexive Banach space and a normed space to represent all bounded linear functionals of the latter. We also give two applications to singular differential equations.

Multiple solutions of nonlinear BVPs by the quasilinearization process

by *Inara Yermachenko*

We investigate the second and the fourth order boundary value problems (BVP) for Emden-Fowler type differential equations using the quasilinearization process (*I. Yermachenko and F. Sadyrbaev*. Nonlinear Analysis: TMA, Elsevier, Proceedings of the WCNA 2004, Orlando, FL, USA, July 2004, - (to appear)). Namely, we represent the problem $x'' = -q(t)\,|x|^p \operatorname{sign} x, \quad x(0) = x(1) = 0$ (i) in a quasilinear form $x'' + k^2 x = F(t,x), \quad x(0) = x(1) = 0$ (ii) with non-resonant linear part in order the equations (i) and (ii) be equivalent in some bounded domain. We prove that modified problem has a solution of the same oscillatory type as the linear part has. We show that under certain conditions this process can be applied with essentially different linear parts and hence the original problem is shown to have multiple solutions. The results are generalized for the fourth order BVPs with the monotone right sides. The appropriate definition of the type of a solution is given, the quasilinearization process is described and the multiplicity results are obtained. Acknowledgment. *Supported by the project VPD1/ESF/PIAA/04/NP/3.2.3.1/0003/0065*

Oscillation criteria for half-linear partial differential equations via Picone's identity

by *Norio Yoshida*

There is much current interest in studying oscillation properties of solutions of half-linear partial differential equations. We consider the half-linear partial differential equation

$$\sum_{i=1}^{n} \frac{\partial}{\partial x_i}\left(A_i^2(x)|\nabla_A v|^{\alpha-1}\frac{\partial v}{\partial x_i}\right) + (\alpha+1)|\nabla_A v|^{\alpha-1}B(x)\cdot\nabla_A v + C(x)|v|^{\alpha-1}v = 0 \qquad (*)$$

which is a generalization of

$$\nabla\cdot\big(A(x)|\nabla v|^{\alpha-1}\nabla v\big) + (\alpha+1)|\nabla v|^{\alpha-1}B(x)\cdot\nabla v + C(x)|v|^{\alpha-1}v = 0,$$

where $\alpha > 0$, $\nabla = (\partial/\partial x_1, ..., \partial/\partial x_n)$ and $\nabla_A = (A_1(x)\partial/\partial x_1, ..., A_n(x)\partial/\partial x_n)$. We establish a Picone identity for $(*)$, and obtain oscillation criteria for $(*)$ using the Picone identity. Reducing the oscillation problem for $(*)$ to a one-dimensional oscillation problem for half-linear ordinary differential equations of the form

$$(r^{n-1}a(r)|y'|^{\alpha-1}y')' + r^{n-1}c(r)|y|^{\alpha-1}y = 0,$$

we derive various oscillation results for $(*)$.

On the existence of business cycles in a two-regional model with fixed exchange rates

by *Rudolf Zimka*

A five-dimensional nonlinear model describing the development of outputs, interest rates and money supplies in two economies connected through mutual trade and capital movement is analysed. Sufficient conditions for the existence of equilibrium, its stability and the existence of business cycles are found.

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