MATHEMATISCHES FORSCHUNGSINSTITUT OBERWOLFACH

Tagungsbericht 11/1999

Gewoehnliche Differentialgleichungen: Harmonic, Subharmonic, Homoclinic and Heteroclinic Solutions

14.03.-20.03.1999

The conference was organized by J. Mawhin (Louvain–la–Neuve), K. Schmitt (Salt Lake City), and H.O. Walther (Giessen). It was attended by 47 participants from 10 European countries (Belgium, Czech Republic, Germany, France, Italy, the Netherlands, Poland, Portugal, Spain, Switzerland), from Russia, and from the U.S.A.
There were 32 lectures. In addition, several evening sessions were organized, all well attended despite the admittedly full program. A special feature of the conference was the unusually high number of young colleagues with most interesting contributions. The largest group of lectures dealt with complicated dynamics near homoclinic and heteroclinic connections, often in reversible and Hamiltonian Systems and including, for example, detailed results on exponentially small splitting of separatrices, and on complicated bifurcation phenomena in Josephson junctions. Harmonic and subharmonic solutions were discussed in a next group of lectures, with one result on infinitely many periodic points of area preserving diffeomorphisms.
Several lectures applied topological and variational methods to Ordinary and Partial Differential Equations. An interesting aspect of this was that these methods now yield detailed information about solution properties (nodal properties of solutions of elliptic boundary value problems, chaotic solutions of O.D.E.'s). A further group of lectures was devoted to infinite–dimensional dynamical systems, with emphasis on global attractors and on periodic, homoclinic, waveform, and super–high frequency solutions of Partial, Lattice, and Delay Differential Equations.
Two lectures discussed stationary solutions of P.D.E.'s with transformed argument.
Last but not least, a small group of lectures involved numerical methods – we mention in particular the very last lecture on chaos in the planar restricted Three–Body–Problem.

It is a pleasure to mention the efficient and friendly assistance of the members and staff of the institute, and the stimulating atmosphere always present in Oberwolfach. The weather was unexpectedly good after a winter with much snow and permitted an excursion to St. Roman.

Vortragsauszüge

A. ABBONDANDOLO:

Subharmonic solutions of Hamiltonian systems

A remarkable theorem by John Franks (Inventiones Math. 1992) states that every area–preserving homeomorphism of the disc with at least 2 fixed points must have ∞–many periodic points. Natural generalizations of such result should concern $2n$–dimensional periodic Hamiltonian systems. Under nondegenerance conditions, we prove the existence of infinitely many subharmonics for asymptotically linear Hamiltonian systems with at least 2 periodic solutions, using a suitable version of Morse-Floer-theory.

A. AMBROSETTI:

On perturbation in critical point theory and applications

Let E be a Hilbert space and consider a class of functionals $f_\varepsilon \in \mathcal{C}^2(E;\mathbb{R})$ of the form

$$f_\varepsilon(u) = f_0(u) + \varepsilon G(u)$$

where $\varepsilon \in \mathbb{R}$ is a real parameter, $G \in \mathcal{C}^2(E,\mathbb{R})$ and f_0 satisfies:
1) there exists a finite dimensional manifold Z such that $f_0'(z) = 0, \forall z \in Z$.
2) $\forall z \in Z, f_0"(z)$ is Fredholm of index 0;
3) $\forall z \in Z, Ker f_0"(z) = T_z Z$.
Theorem: Let $(1-2-3)$ hold and let $\Gamma := G|_Z$. If $\overline{z} \in Z$ is a critical point of Γ such that $deg_{loc}(\Gamma', 0) \neq 0$, then f_ε has a critical point u_ε and $u_\varepsilon \to \overline{z}$ as $\varepsilon \to 0$.
The preceding theorem provides a general frame for many perturbative problems. Here we discuss the following one:

$$(1) \qquad \begin{cases} -\Delta u = [1+\varepsilon K(x)] u^{\frac{n+2}{n-2}} & x \in \mathbb{R}^n, n \geq 3 \\ u > 0, u \in \mathcal{D}^{1,2}(\mathbb{R}^n) \end{cases}$$

Eq. (1) arises in the prescribed Scalar Curvature problem. For example, one can show the following result:
Suppose that $K \in \mathcal{C}^2 \cap L^\infty, \int K'(x) \cdot x < 0$ and $K'(x) \cdot x < 0$ for $|x| \geq 1$. Let ξ_i denote the critical points of K and assume they are non–degenerate and such that $\Delta K(\xi_i) \neq 0$. Then (1) has a solution for ε small provided

$$\sum_{\Delta K(\xi_i) < 0} (-1)^{m_i} \neq (-1)^n \quad , m_i := \text{ Morse index of } \xi_i.$$

Actually this is a particular case of more general results.

T. BARTSCH:

Sign changing solutions of elliptic Dirichlet problems

We refine a number of existence results for solutions of

$$(D) \qquad \begin{cases} -\Delta u = f(u) & \text{in } \Omega \\ u = 0 & \text{on } \partial\Omega \end{cases}$$

where $\Omega \subset \mathbb{R}^N$ is a smooth domain, $f \in C^1(\mathbb{R})$. Let SC be the set of sign changing solutions of (D). SC is ordered by

$$u \le v \quad :\Longleftrightarrow \quad u(x) \le v(x) \text{ for all } x \in \Omega.$$

If f is superlinear, subcritical and odd in u then the symmetric mountain pass theorem yields an unbounded sequence of solutions of (D). We can show that there exists an unbounded sequence of solutions $u_k \in SC$ which are both maximal and minimal in SC. In fact, each u_k is a maximal element in the set of all sign changing supersolutions, and a minimal element in the set of all sign changing subsolutions.
Another result which we can prove for a large class of nonlinearities is the existence of a sign changing solution $u_1 \in SC$ which is again a minimal and a maximal element of SC, and which has precisely two nodal domains. Moreover, its critical groups are like those of a nondegenerate solution of (D) with Morse index 2. This additional information can be used for new existence results.

M. BERTI:

Homoclinics and chaos for systems with a saddle–saddle equilibrium

We consider autonomous Lagrangian systems with two degrees of freedom, having an hyperbolic equilibrium of SADDLE–SADDLE type (that is the eigenvalues of the linearized system are $\pm\lambda_1, \pm\lambda_2, \lambda_1, \lambda_2 > 0$). Under a non–degeneracy condition on the homoclinics and under suitable conditions on the geometric behaviour of these homoclinics near the equilibrium we prove, by variational methods, that they give rise to an infinite family of multibump homoclinic solutions and that the topological entropy at the zero energy level is positive. We can deal also with homoclinics which are just ‘topologically transversal’.

M. BÜGER:

Periodic motion in autonomous reaction–diffusion systems

We consider the system

$$(RD) \quad \frac{d}{dt}\begin{pmatrix} u \\ v \end{pmatrix} = \lambda\Delta\begin{pmatrix} u \\ v \end{pmatrix} + \begin{pmatrix} u \\ v \end{pmatrix} \cdot f(u,v)\begin{pmatrix} -v \\ u \end{pmatrix} \quad \text{in } \Omega = (0,1), \begin{pmatrix} u \\ v \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \end{pmatrix} \quad \text{on } \partial\Omega$$

of two reaction–diffusion equations for $\lambda > 0$ and $f \in C^1(\mathbb{R}^2, \mathbb{R})$ as a model system for the more general case

$$\frac{d}{dt}\begin{pmatrix} u \\ v \end{pmatrix} = \lambda\Delta\begin{pmatrix} u \\ v \end{pmatrix} + h(u,v) \quad \text{in } \Omega, \begin{pmatrix} v \\ v \end{pmatrix} = \begin{pmatrix} 0 \\ \acute{a} \end{pmatrix} \qquad \text{on } \partial\Omega.$$

We introduce the set of so called 'planar solutions' of the form

$$\begin{pmatrix} u \\ v \end{pmatrix} = r \cdot \begin{pmatrix} \cos(t+\varphi_0) \\ \sin(t+\varphi_0) \end{pmatrix}$$

These planar solutions are easy to treat and many well known results can be applied. We show that all solutions of (RD) tend either to zero of to a planar and periodic solution. In order to get this Poincaré–Bendixson result, we show that the ω–limit set of any initial value consists of planar elements. Furthermore, we prove some stability results for these periodic orbits.

M.-C. CIOCCI:

Bifurcation and stability of periodic orbits in reversible or symplectic diffeomorphisms

We survey some recent results on the bifurcation of periodic points in reversible or symplectic diffeomorphisms; such diffeomorphisms arise for example as Poincaré maps in reversible of Hamiltonian autonomous systems. We show how this bifurcation problem can be reduced to a similar problem on a 'reduced phase space' having an additional $\mathbb{Z}_q$–symmetry, and in such a way that the reversibility or symplecticity is preserved; the reduced diffeomorphism can also be approximated via the normal form. This normal form is also very helpful for studying the stability of bifurcating periodic orbits. We apply our general results to a simple case of generic bifurcation of periodic orbits in a one–parameter family of reversible diffeomorphisms; we find two bifurcating branches, one stable, the other unstable.
This is joint work with André Vanderbauwhede (University of Gent).

M. EFENDIEV:

Upper and lower bounds for the Hausdorff dimension of the attractor for reaction–diffusion equations in R^n

We study the existence of uniform attractor A_{un} for reaction–diffusion equations of the form

$$\begin{cases} \frac{\partial u}{\partial t} &= \nu\Delta u - f(u) - \lambda_0 u + g_0(x,t) \\ u|_{t=0} &= u_0, \lambda_0 > 0, x \in R^n \end{cases}$$

when forcing term depends quasiperiodically on the time, that is $g_0(x,t) = \tilde{g}_0(x, \alpha_1 t, \ldots, \alpha_k t)$. For the Hausdorff dimension of the uniform attractor A_{un} we obtain upper bounds

$$\dim_{Hausd} A_{un} \le k + C_1 k^{\frac{n}{n+4}} + C_2 \nu^{\frac{-n}{2}}.$$

Moreover, for a class of non–monotone nonlinearities $\varphi(u) := f(u) - \lambda_0 u$, we prove upper and lower estimate for the Hausdorff dimension of the global attractor A_{gl} of the form

$$C_1(\lambda_0)\nu^{\frac{-n}{2}} L^n \le \dim_{Hausd} A_{gl} \le C_2(\lambda_0)\nu^{\frac{-n}{2}} L^n$$

where $g = g_L(x), L \ge L_0 > 0, L_0$ is some given real number. We discuss also some open problems related to the talk.

A. FONDA:

Nonlinear resonance in asymmetric oscillators

The simple nonlinear equation

$$x'' + cx' + g(x) = f(t),$$

with

$$g(x) = \begin{cases} \mu x & \text{if} \quad x \ge 0 \\ \nu x & \text{if} \quad x < 0 \end{cases}, \quad \mu > 0, \nu > 0,$$

models an asymmetric oscillator with a friction coefficient $c \ge 0$ and forcing term $f(t)$. When $f(t)$ is T–periodic, we speak of 'nonlinear resonance' if μ and ν satisfy

$$\frac{1}{\sqrt{\mu}} + \frac{1}{\sqrt{\nu}} = \frac{T}{n\pi},$$

for some positive integer n. In this case, conditions on f can be given to prove multiplicities of periodic solutions of period T or multiples of T (subharmonic). Some of these have amplitudes going to infinity as $c \to 0$ and can be proved to be asymptotically stable.
Similar results can be proved in case $f(t)$ is almost periodic instead of periodic, leading to

large amplitude almost periodic solutions.

T. GEDEON:

Infinite gain neural networks

We consider dynamics of

$$x_i' = -x_i + \Lambda_i(x_1, \ldots, \hat{x}, \ldots x_n), i = 1 \ldots n$$

where Λ_i only depends on $\text{sgn}x_1, \ldots \text{sgn}x_n$ and not on $\text{sgn}x_i$.
Functions Λ_i are discontinuous along hyperplanes $x_j = 0$. We define a Morse decomposition of the related projective flow, based on the graph of interactions associated to the system of equations.
We study attractors in systems with an attractive figure 8 subgraph. We show that a symmetric attractor of this type is either a figure 8 periodic orbit or a pair of fixed points. We also show that if the values of Λ_i's lie only in the values of a hypercube in R^n, there is no complicated dynamics in the system.

V. GELFREICH:

Splitting of a small separatrix loop near the saddle–center bifurcation in area–preserving maps

When the saddle–center bifurcation occurs in an analytic family of area–preserving maps, first a parabolic fixed point appears at the origin and then this point bifurcates, creating an elliptic and hyperbolic fixed point. Separatrices of the hyperbolic fixed point form a small loop around the elliptic point. In general the separatrices intersect transversely and the splitting is exponentially small with respect to the perturbation parameter. We derive an asymptotic formula, which describes the splitting, and study the properties of the preexponential factor.

S. VAN GILS:

Coupled Josephson junctions
(Joint work with Martin Krupa (TU Wien) and Victor Tchistiakov)

We analyse the dynamics of two identical Josephson junctions coupled through a purely capacitive load in the neighbourhood of a degenerate symmetric homoclinic orbit. A bifurcation function is obtained applying Lin's version of Lyapunov–Schmidt reduction. We locate in parameter space the region of existence of n–periodic orbits, and we prove the existence of n-homoclinic orbits and bounded non–periodic orbits. A singular limit of the bifurcation function yields a one dimensional mapping which is analyzed, Numerical computations of non–symmetric homoclinic orbits have been performed, and we show the relevance of these computations by comparing the results with the analysis.

M. HĂRĂGUŞ–COURCELLE:

Travelling waves of the KP equations with transverse modulations

Kadomtsev–Petviashvili (KP) equations arise generically in modelling nonlinear wave propagation for primarily unidirectional long waves of small amplitude with weak transverse dependence. In the case when transverse dispersion is positive (such as for water waves with large surface tension) we investigate the existence of transversely modulated travelling waves near one–dimensional solitary waves. Using bifurcation theory we show the existence of a unique branch of periodically modulated solitary waves. Then, we discuss the case when the transverse dispersion is negative (such as for water waves with zero surface tension). Here, we find that given a positive wave speed, and given essentially arbitrary small amplitude data for the wave amplitude and its transverse derivative along a single line in the direction of propagation, a complete travelling wave surface is determined. This suggests that water wave propagation can sustain a plethora of complicated steady wave patterns in three dimensions.

C. JONES:

Dynamical systems issues arising in studying the ocean

In the recirculation of fluid past an island, under the influence of wind forcing, a 'dead zone' appears. Dynamical systems techniques can be used effectively to asses the quantities of fluid involved in an exchange between the dead zone and the ambient water as the wind forcing creates strong time–dependence. Heteroclinic orbits are determined in a numerical model, the tangles of which create the regions of fluid being exchanged. It is shown that this effect of 'chaotic advection' far exceeds the leakage due to Ehrmann pumping even at moderate levels of forcing. The determination of the relevant stable and unstable manifolds requires some development as they emanate from effectively hyperbolic regions in a numerical velocity field and not analytically prescribed fixed points.
A Melnikov theory is also discussed for cases without boundary. A formula is given that shows small viscosity and forcing can cause the separation of stable and unstable manifolds. This talk is based on joint work with Sandstede (Ohio State), Miller (Stevens Inst. of Tech.), Pratt and Helfrich (Woods Hole), and Balasuriyn (Peradeniya).

H. KIELHÖFER:

Pattern formation of the stationary Cahn–Hilliard model

We investigate critical points of the free energy $E_\varepsilon(u)$ of the Cahn–Hilliard model over the unit square under the constraint of a mean value m. We show that for any fixed value m in the so–called spinodal region and to any mode of $D_u E_\varepsilon(m)$ there are critical points of $E_\varepsilon(u)$ having the characteristic symmetries and monotonicities of that mode provided $\varepsilon > 0$ is small enough. As ε tends to zero these critical points have singular limits where the symmetries and monotonicities are preserved. Therefore they form characteristic patterns for each mode.
It is remarkable that all singular limits are global minimizers of $E_0(u)$ which is not obvious since minimizing properties of the critical points of $E_\varepsilon(u)$ are not known.
Our method consists of a global bifurcation analysis of critical points of the energy $E_\varepsilon(u)$ where the bifurcation parameter is the mean value m. This new analytic approach suggests a path following device to obtain the critical points of $E_\varepsilon(u)$ (near global minimizers of $E_0(u)$) numerically.

K. KIRCHGÄSSNER:

Dynamics of a chain of coupled nonlinear oscillators

The lecture covers joint work with Gérard Iooss from Nice. A one–dimensional chain of nonlinear oscillators is considered with nearest neighbor interaction. Ruling parameters are the coupling intensity and the distance of immediate neighbors. A method is described to classify all travelling waves of moderate amplitude in such a chain. These waves owe their existence to certain resonances which are completely discussed in the parameter plane. The main methods used are a suitable extension of the original formulation, which handles nonlocal terms as boundary values of solutions of certain transport–equations. Moreover, a reduction result allows the use of normal form analyis for the resulting finite dimensional vector field. Applications to homogenization problems are indicated.

U. KIRCHGRABER:

Computer–assisted proof of chaotic behaviour: Application to a three–body–problem

In this talk I report on joint work with D. Stoffer which is related to earlier joint work with K. Palmer and our students C. Hundig and T. Notter.
The idea, due to Stoffer, is to prove chaotic behaviour by numerically constructing two

nearly periodic hyperbolic orbits which approach each other very closely at some point and using (numerical) shadowing. Chaotic behaviour means that the Bernoulli shift can be embedded. The considerably refined scheme proposed in this talk is shown to apply to the planar restricted problem of three bodies with equal masses of the primaries.
Strictly speaking we do not rigorously establish chaotic behaviour since we use what we call 'realistic estimated bounds' rather than 'validated bounds' (in the sense of interval arithmetics).

J. KNOBLOCH:

Dynamics near connecting orbits in discrete dynamical systems

We consider discrete dynamical systems having for a certain parameter a homoclinic orbit approaching to a hyperbolic fixed point. We are interested in the dynamics in a neighborhood of such a homoclinic orbit. In particular we consider transversal homoclinic points and the case where stable and unstable manifolds have quadratic tangencies. In both cases we use Lin's method to construct Poincaré maps which are conjugated to a shift map.

T. KRIECHERBAUER:

On the dynamics of nonlinear lattices

In this talk we discuss the dynamics of one–dimensional lattices $(x_n)_{n\geq 1}$ with nearest neighbor interactions,

$$\ddot{x}_n = F(x_{n-1} - x_n) - F(x_n - x_{n+1}), \quad n \geq 1,$$

initially at rest, and which are driven from one end by a particle x_0. The driver, x_0, is assumed to undergo a prescribed motion,

$$x_0(t) = at + \varepsilon h(\gamma t),$$

where a, ε, γ are real constants and $h(\cdot)$ has period 2π. We describe the numerically observed behaviour (shock and rarefaction phenomena for $\varepsilon = 0$, generation of multi–phase travelling waves for $\varepsilon \neq 0$) and present corresponding analytical results.
First, we discuss the integrable model $F(x) = e^x$ (Toda lattice). In this particular case one can rigorously derive the long–time asymptotics for a large class of initial value problems using the Inverse Scattering Transform (IST) method.
Secondly, we present results which apply to general classes of nonlinear force laws F,

which establish the existence of families of (quasi –) periodic travelling waves by perturbative methods (bifurcation analysis; KAM methods).

B. LANI–WAYDA:

Multidimensional Poincaré maps and one–dimensional observations

In practical experiments, e.g., with neuron cells, one typically observes only a few components of a higher dimensional system, or even only one component. For example, one measures the output voltage of a neuron, the state of which is determined by many further variables.

Assume that the high dimensional system has a periodic trajectory and an associated Poincaré map P. We describe the connection between the map P and the orbits of another map, which arises from the interpretation of one-dimensional data as return times. We prove that these maps are locally conjugate by a transformation which generically is a diffeomorphism. An explicit criterion for invertibility of the local transformation is derived, and discussed in view of numerical experiments of B. Eckhardt (Dep. of Physics, Univ. Marburg) with Hodgkin–Huxley type equations.

R. LAUTERBACH:

Heteroclinic cycles in symmetric systems

We discuss the stability of an object which we call a generalized heteroclinic cycle. This object occurs in dynamical systems with spherical symmetry when the symmetry group $\mathbf{O}(3)$ acts as the sum of its three and its five dimensional irreducible representation. The term generalized heteroclinic cycle refers to the fact that besides the multiplicities due to the group action there is an additional degeneracy: one of the connections is replaced by a higher dimensional set of connecting orbits. This generalized heteroclinic cycle comes up in a simple model to study pole reversals of the earth' magnetic field.
Due to the high dimension of the underlying space it is difficult to do the stability analysis similar to the analysis of Krupa and Melbourne. Therefore we employ geometric techniques to understand the dynamics. The tools are stratifications by orbit type, orbit space reductions and a rather explicit understanding of the stratification by orbit types on the orbit space. Due to normal hyperbolicity of the group orbits of equilibria we can restrict to what we call the local orbit space: consider a slice to the group orbit and the orbit space reduction with respect to the isotropy subgroup. This construction gives us precise geometric decompositions of slices to stable and unstable manifolds and allows to restrict the form of local and global maps between these slices. Putting this information together we can give a criterion for the stability of the generalizd heteroclinic cycle.

E. LOMBARDI:

Phenomena beyond all orders and bifurcations of homoclinic reversible connections

We explain how to obtain an exponentially small equivalent of an oscillatory integral when it involves solutions of a nonlinear differential equation. The method proposed enables us to study the problem of existence of homoclinic connections to 0 for vector fields admitting a $0^2 i\omega$ resonance at the origin. This problem could not be solved by a direct application of the classical Melnikov method since the Melnikov function is given in this case by an exponentially small oscillatory integral.

S. MAIER-PAAPE:

Structure of the attractor for the Cahn–Hilliard and Allen–Cahn equation

For certain parameter values we numerically calculate the set of equilibria for these equations with a path–following method. This case study is performed for the cubic nonlinearity and a square domain. The numerical data are then used to build connection matrices which basically describe heteroclinic connections between the equilibria. Eventually a semiconjugacy of the flow on the attractor to the flow of several toy models is established.
Joint work with U. Miller (U. Augsburg, numerics part), K. Mischaikow (Georgia Tech.), and T. Wanner (Univ. of Maryland, Baltimore, topology part).

J. MALLET-PARET:

Crystallographic pinning in spatially discrete systems

We study dynamical phenomena for a class of lattice differential equations, namely infinite systems of ordinary differential equations coordinatized by points on a spatial lattice (for example, the integer lattice in the plane). We examine in particular the occurence of travelling wave solutions, and their dependence on the direction of motion on the travelling wave.
The phenomenon of crystallographic pinning occurs when there is a tendency for a wave to become pinned (that is, to cease moving) in selected directions. In previous work with John Cahn and Erik Van Vleck we demonstrated this phenomenon for a special class of systems with piecewise linear nonlinearities. In the present work, we show how this phenomenon holds for a general class of systems with smooth nonlinearities (including spatially discrete Allen–Cahn equations), and how it follows from general principles of dynamical systems.

A. MIELKE:

Multibump solutions to a saddle–focus in the reversible and $SO(2)$–invariant case

Motivated by the slightly subcritical Poiseuille flow we consider 4–dimensional ODEs with a saddle–focus equilibrium (ev's $\pm(1\pm i\omega)$) having a homoclinic solution. One example is the steady one–dimensional complex Ginzburg–Landau equation

$$(*) \qquad A_{xx} - (1+i\omega)^2 A + \hat{c}|A|^2 A = 0$$

with the Stewartson–Stuart pulse $A(x) = (\cosh x)^{-1(1+i\omega)}$ when $\hat{c}_0 = (1+i\omega)(2+i\omega)$. Perturbing $\hat{c}$ in the form $\hat{c} = (1+i\varepsilon)\hat{c}_0$ this pulse is destroyed and multibump solutions of $(*)$ can be shown to exist on sequences $(\varepsilon_k^n)_{k\in N}$ with $\varepsilon_k^n \to 0$ for $k \to \infty$. Here $n \geq 2$ denotes the number of bumps.
In addition, n–periodic solutions as well as chaotic solutions in a neighbourhood of the primary pulse are constructed.

R. NUSSBAUM:

Super–high frequency solutions for a discontinuous differential–delay equation and nonexpansive operators on $l_1(\mathbb{Z})$

Consider the following initial value problem for a nonlinear differential–delay equation:

$$(1) \qquad x'(t) = -\mathrm{sgn}(x(t-1)) + f(x(t)), \quad t \geq 0$$
$$x|[-1,0] = \varphi \in C([-1,0])$$

Here we define $\mathrm{sgn}(u) = +1$ for $u > 0, \mathrm{sgn}(0) = 0$ and $\mathrm{sgn}(u) = -1$ for $u < 0$. By a solution $x(t) := x(t;\varphi)$ of (1) we mean a continuous function $x : [-1,\infty) \to \mathbb{R}$ which is absolutely continuous on $[0,\infty)$ and satisfies (1) for almost all $t \geq 0$. If f is locally Lipschitzian, we prove that such a solution is uniquely determined. A solution $x(t;\varphi)$ of (1) is called a super–high frequency solution of (1) if, for each $t \geq 0$, there exist infinitely many $s \in (t-1,t]$ such that $x(s) = 0$.

Theorem 1. Assume that f is locally Lipschitzian and $|f(u)| \leq c < 1$ for all $u \in \mathbb{R}$. Then $x(t_i\varphi)$ is not a super–high frequency solution of (1) unless $\varphi = 0$ and $f(0) = 0$.

It turns out that an essential role in discussing eq. (1) is played by a certain nonlinear operator defined in $l_1(\mathbb{Z})$, the Banach space of absolutely summable, biinfinite sequences $x =< x_n | n \in \mathbb{Z} >$. Define $K = \{x \in l_1(\mathbb{Z}) : x = (x_n) \text{ and } x_n \geq 0 \text{ for all } n \in \mathbb{Z}\}$ and for $R > 0$ define $K_R = \{x \in |||x||_{l_1(\mathbb{Z})} \leq R\}$. Let $\sigma : [0, R] \to [0, R]$ and $\tau : [0, R] \to [0, R]$ denote continuous increasing functions with $\sigma(0) = \tau(0) = 0$. Assume that there exists $\lambda, 0 < \lambda < \frac{1}{2}$, such that

$$(2) \qquad \lambda \leq \frac{\sigma(t) - \sigma(s)}{t - s} \leq 1 - \lambda \quad \text{and} \quad \lambda \leq \frac{\tau(t) - \tau(s)}{t - s} \leq 1 - \lambda \text{ for } 0 \leq s < t \leq R.$$

Define $F : K_R \to K_R$ by $F(x) = y$ where $y_{2n} = \sigma(x_{2n}) + \tau(x_{2n-1})$ and $y_{2n+1} = x_{2n+1} - \tau(x_{2n+1}) + x_{2n} - \sigma(x_{2n})$. For $x \in l_1(\mathbb{Z})$, define $\|x\|_\infty = \sup\{|x_n| : n \in \mathbb{Z}\}$.

Theorem 2. $F : K_R \to K_R$ is order–preserving, integral–preserving and nonexpansive with respect to the $l_1(\mathbb{Z})$ norm. For each $\varepsilon > 0$, there exists $N(\varepsilon, R)$ such that $\|F^n(x)\|_\infty \leq \varepsilon$ for all $n \geq N(\varepsilon, R)$ and all $x \in K_R$.

We introduce a large generalization of the operator F and show that the analogue of Theorem 2 holds for this generalized class of operators.

R. ORTEGA:

The dynamics of an asymmetric oscillator

Let $C = S^1 \times \mathbb{R}$ be a cylinder with coordinates $(\theta, r), \theta = \theta + 2\pi, r \in \mathbb{R}$ and let

$$f_\delta : A \subset C \to C, (\theta, r) \mapsto (\theta_1, r_1), \quad A = S^1 \times [a, b],$$

be a family of mappings $\{f_\delta\}_{\delta \in [0,1]}$ satisfying the intersection property and having the expansion

$$\theta_1 = \theta + \omega + \delta l_1(\theta, r) + o(\delta), r_1 = r + \delta l_2(\theta, r) + o(\delta).$$

If ω is not commensurable with 2π and

$$\int_0^{2\pi} \frac{\partial l_1}{\partial r}(\theta, r) d\theta > 0$$

then f_δ has invariant curves for small δ.
As a consequence of this variant of the Small Twist Theorem one deduces that the solutions of

$$\ddot{x} + ax^+ - bx^- = f(t), a \neq b, f \in C^4(\mathbb{R}/2\pi\mathbb{Z})$$

are bounded if $\frac{1}{\sqrt{a}} + \frac{1}{\sqrt{b}} \notin \mathbb{Q}$ and $\int_0^{2\pi} f(t) dt \neq 0$. Moreover, the dynamics at infinity is of twist type.

C. REBELO:

Rotation numbers and solutions to nonlinear boundary value problems

We consider systems of the form

$$Z' = Z(t, z_i s)$$

where $Z = Z(t, z_i s) : [0, T] \times \Omega \times I \to \mathbb{R}^2$ is a continuous function, Ω is an open domain in $\mathbb{R}^2$ and $s \in I$ is a real parameter, and prove existence and multiplicity of solutions to associated boundary value problems using sharp estimates on rotation numbers. The results we obtain are of two kind: In one hand we prove existence of periodic (harmonic and subharmonic) solutions combining the estimates on the rotation numbers with the Poincaré–Birkhoff fixed point theorem, on the other we prove existence of branches of nodal solutions for Sturm–Liouville problems. These last results are obtained combining estimates on rotation numbers with a topological lemma which can have an independent interest.
These results were obtained in joint works with Fabio Zanolin.

L.E. ROSSOVSKII:

Boundary value problems for elliptic functional differential equations with contractions

Consider the boundary value problem

$$Au = \sum_{k=0}^{l} \sum_{|\alpha| \le 2m} a_{\alpha k}(x) D^\alpha (u(q^{-k}x)) = f_0(x) \quad (x \in Q),$$

$$T_j u|_{\partial Q} = f_j(x) \quad (j = 1, \dots, m; x \in \partial Q),$$

where $q > 1, Q \subset \mathbb{R}^n$ is a smooth bounded domain such that $\overline{Q} \subset qQ, a_{\alpha k} \in C^\infty(\overline{Q})(k = 0, \dots, l; |\alpha| \le 2m); T_j(x, D)$ are differential operators of order m_j with smooth coefficients. We assume that the operator $A_0(x, D) = \sum_{|\alpha|=2m} a_{\alpha 0}(x) D^\alpha$ is properly elliptic, and that the operators $T_j(x, D)$ satisfy the Lopatinskii condition with respect to $A_0(x, D)$. Let $Lu = (Au, T_1 u|_{\partial Q}, \dots, T_m u|_{\partial Q})$ and $L_0 u = (A_0 u, T_1 u|_{\partial Q}, \dots, T_m u|_{\partial Q})$. Introduce the symbol $a(x, \xi, \lambda)$ of the operator A by the formula

$$a(x, \xi, \lambda) = \sum_{k=0}^{l} \sum_{|\alpha|=2m} a_{\alpha k}(x) \xi^\alpha \lambda^\alpha \quad (x \in \overline{Q}, \xi \in \mathbb{R}^n, \lambda \in \mathbb{C}).$$

Theorem. Under the condition $a(0, \xi, \lambda) \neq 0 \quad (|\lambda| \le q^{n/2-2m}; 0 \neq \xi \in \mathbb{R}^n)$ the operator

$$L : W_2^{s+2m}(Q) \to W_2^s(Q) \times \Pi_{j=0}^m W_2^{s+2m-m_j-2m}(\partial Q)$$

is Fredholm ($s \geq 0$).

To prove this result we consider pseudodifferential operators with contractions and construct the regularizer P of the operator L in the form $P = P_0 B$. Here P_0 is the regularizer of $L_0, B = \begin{pmatrix} B(x,D,R) & 0 \\ 0 & E \end{pmatrix}$, $B(x,D,R)u(x) = u(x) + \sum_{k=1}^{\infty} B_k(x,D)[(\varphi u)(q^{-1}x)]$, $B_k(x,D)$ are pseudodifferential operators of the zero order, $\varphi \in \dot{C}^{\infty}(Q)$ is a suitable cutoff function, by 0 we denote the m–dimensional row and column, E is the identity matrix of order $m \times m$.

B. SANDSTEDE:

Self–replicating patterns in the Gray–Scott model

The Gray–Scott model, a coupled reaction–diffusion system on an interval, describes a certain autocatalytic chemical reaction. Numerically, it exhibits self–replicating patterns: a pulse splits into two identical pulses that move apart and start to replicate againg. This phenomenon repeats itself in the following fashion: at each step, the two outer pulses replicate so that a sequence of $2 \to 4 \to 6 \to 8 \to \ldots$ pulses occurs. In a joint work with S.-I. Ei and Y. Nishiura, we presented a mechanism that explains this intriguing phenomenon using recent results on the interaction of pulses.

A. SCHEEL:

Dynamics of pulses, fronts and Turing patterns

We study bifurcations from fronts and pulses due to essential spectrum crossing the imaginary axis. As an example we treat the case where the aysmptotic state undergoes a Turing instability. We prove that under typical assumptions, the reaction–diffusion system possesses modulated fronts, asymptotic to Turing patterns when those are created ahead of the front. On the other hand, no modulated fronts exist when the instability occurs behing the front. Pulses are shown to create a recovery zone when they move through a Turing pattern. Stability of bifurcating solutions is treated in all cases.

K.R. SCHNEIDER:

Singular boundary value problems

We consider the class of bounday value problems

$$(*) \begin{cases} \varepsilon^2 d^2u/dx^2 = g(u,v,x,\varepsilon), \quad d^2v/dx^2 = f(u,v,x,\varepsilon), \\ u'(0) = u'(1) = 0, v(0) = v^0, \quad v(1) = v^1, x \in (0,1), 0 < \varepsilon << 1. \end{cases}$$

The crucial assumption is that the degenerate equation $g(u, v, x, 0) = 0$ has at least two intersecting solutions (exchange of stabilities). Under this assumption, the standard theory of singularly perturbed systems is not applicable. Problems of that type arise in describing steady–state solutions of reaction–diffusion systems in chemical kinetics with fast bimolecular reactions.
The method to establish existence of (at least one) solution of $(*)$ is based on the techniques of ordered asymptotic upper and lower solutions. We give an explicit construction of these solutions by means of the so–called singular stable solution to $(*)$. The order of the asymptotic approximation of a solution of $(*)$ near the intersection points of the solutions of the degenerate equation is $O(\sqrt{\varepsilon})$, outside some small neighbourhood we get any order of approximation provided f and g are sufficiently smooth.

E. SERRA:

Homoclinic solutions to periodic motions in pendulum–type equations

We consider a class of scalar nonautonomous equations which generalize the forced pendulum equation. These equations admit an ordered set of periodic solutions. We construct classes of solutions which behave asymptotically as the periodic minimizers. In particular we find: 1) heteroclinic solutions connecting two periodic minimizers; 2) existence of multibump–type solutions, including solutions with infinitely many bumps.
The existence of these types of solutions shows that the dynamics associated to the problem exhibits some aspects of chaoticity. The methods are variational, the main tool being constrained minimization.

A.L. SKUBACHEVSKII:

Solvability and index of nonlocal elliptic problems

Let $Q \subset \mathbb{R}^n$ be an open bounded domain with a boundary $\partial Q = \bigcup_i \overline{\Gamma}_i (i = 1, ..., N_0)$, where Γ_i are the open connected $(n-1)$–dimensional manifolds of class C^∞; $n \geq 2$. We suppose that in a neighbourhood of each point $g \in \partial Q \backslash \bigcup_i \Gamma_i$ the domain Q is diffeomorphic to an n–dimensional angle.
We consider the nonlocal problem

(1) $$A(x, D)u(x) = f_0(x) \qquad (x \in Q \setminus K),$$

(2) $$B_{i\mu}u(x) = \sum_{s=0}^{M_i} B_{i\mu s}(x, D)u(\omega_{is}(x))|_{\Gamma_i} = f_{i\mu}(x)$$

$$(x \in \Gamma_i; i = 1, \dots, N_0; \mu = 1, \dots, m).$$

Here $A(x,D), B_{i\mu s}(x,D)$ are the differential operators of orders $2m$ and $m_{i\mu}$, respectively; the operator $A(x,D)$ is properly elliptic, the system $\{B_{i\mu 0}(x,D)\}_{\mu=1}^{m}$ is normal and covers the operator $A(x,D)$; ω_{is} are infinitely differentiable nondegenerate transformations mapping some neighbourhood Ω_i of Γ_i into the set $\omega_{is}(\Omega_i)$ so that $\omega_{is}(\Gamma_i) \subset Q$ and $\omega_{is}(\overline{\Gamma}_i) \cap (\bigcup_i(\overline{\Gamma}_i \setminus \Gamma_i)) = \phi\,(s = 1, \dots, M_i; i = 1, \dots, N_0)$, $\omega_{i0}(x) \equiv x$.
We suppose that the set K is given by

$$K = K_1 \bigcup \{\bigcup_{i,s} \omega_{i,s}(\overline{\Gamma}_i \setminus \Gamma_i)\} \cup \{\bigcup_{j,p} \bigcup_{i,s} \omega_{jp}(\omega_{is}(\overline{\Gamma}_i \setminus \Gamma_i) \cup \Gamma_j)\}$$

$$(K_1 = \bigcup_i (\overline{\Gamma}_i \setminus \Gamma_i); i,j = 1, \dots, N_0; s = 1, \dots, M_i; p = 1, \dots, M_j)$$

and consists of a finite number of $(n-2)$–dimensional smooth manifolds.
We introduce the weighted space $V^k_{p,a}(Q)(1 < p < \infty, a \in \mathbb{R})$ with a norm

$$\|u\|_{V^k_{p,a}}(Q) = \{\sum_{|\alpha| \le k} \int_Q \rho^{p(a-k+|\alpha|)} |D^\alpha u|^p dx\}^{1/2},$$

where $\rho = \rho(x,K)$.
We define the bounded operators

$$L_0, L : V^{l+2m}_{p,a}(Q) \to V^l_{p,a}(Q) \times \Pi_{i,\mu} V^{l+2m-m_{i\mu}-1/p}_{p,a}(\Gamma_i)$$

by the formulas

$$L_0 u = \{Au, B_{i\mu 0} u|_{\Gamma_i}\}, Lu = \{Au, B_{i\mu} u\}.$$

Theorem. Let the operator L_0 be Fredholmian. Then the operator L is Fredholmian and ind $L =$ ind L_0.

This result was obtained jointy with O.A. Kovalyova.

R. SRZEDNICKI:

On periodic solutions and chaotic dynamics inside isolating chains

For an non–autonomous ordinary differential equation we consider isolating segments, subsets of the extended phase space of the equation, which in some way resemble isolating blocks. The union of several contiguous isolating segments is called an isolating chain. We present a theorem on existence of a periodic solution inside an isolating chain provided the equation is time–periodic. The result will be applied in proofs of the existence of chaotic dynamics for some planar non–autonomous equations.

M. TARALLO:

Forced pendulum–type equations: Degeneracy and dynamics

A natural notion of degeneracy for an equation of the type $\ddot{u} + c\dot{u} = f(t,u)$ (f doubly periodic, $c \geq 0$) is introduced, which is shown to strongly affect the associated dynamics. In particular, nondegeneracy is proved to be a necessary condition in order to have a rich dynamics (subharmonic solutions, homoclinic orbits ...). Recent works showed that nondegeneracy is 'almost' sufficient for the same goal, so making a key point for a better understanding about whether degeneracy really happens or not. To this aim, an explicit parametrization is provided for degenerate equations which highlights some interesting features of the class of all degenerate equations. A similar characterization is provided for first order equations $\dot{u} = g(t,u)$ (g doubly periodic), and the existence of a $1-1$ correspondence between $1^{\underline{\text{st}}}$ order degenerate equations and $2^{\underline{\text{nd}}}$ order degenerate equations is proved. In particular, the degeneracy of $\dot{u} - \sin u = h(t)$ is proved to be equivalent to a finite number of conditions.

M. WILLEM:

Minimization problems on almost cylindrical domains

We consider the minimization problem

$$S_\lambda(\Omega) := \inf_{\substack{u \in H_0^1(\Omega) \\ |u|_{2^*}=1}} \int_\Omega |\nabla u|^2 - \lambda u^2$$

when $\Omega \subset \mathbb{R}^N$ is almost cylindrical, $N \geq 4$ and $2^* = 2N/(N-2)$.
We assume that $0 < \lambda < \lambda_1(\Omega)$ when

$$\lambda_1(\Omega) := \inf_{\substack{u \in H_0^1(\Omega) \\ |u|_2=1}} \int_\Omega |\nabla u|^2,$$

and that
(H_1) for some bounded domains F, G, $\quad \hat{F} \subset \Omega \subset \hat{G}$
$(H_2) \forall \delta > 0 \exists M > 0 \forall |t| \geq M, \Omega^t \subset F_\delta$.

We use the following notations:

$$\begin{aligned} A \subset \mathbb{R}^{N-l}, \hat{A} &= \mathbb{R}^l \times A \\ A_\delta &= \{y \in \mathbb{R}^{N-l} : dist(y,A) < \delta\} \\ \Omega \subset \mathbb{R}^N, \Omega^t &:= \{y \in \mathbb{R}^{N-1} : (t,y) \in \Omega\}. \end{aligned}$$

Under the above assumption $S_\lambda(\Omega)$ is achieved and, after a rescaling we obtain a solution of the problem

$$\begin{cases} -\Delta u - \lambda u &= u^{2^*-1} \\ u \in H_0^1(\Omega), & u > 0. \end{cases}$$

This joint work with Miguel Ramos and Zhi-Quiang Wang depends on a decomposition Lemma for bounded sequence in $L^p(\mathbb{R}^N)$.

C. WULFF:

Spiral waves and bifurcation from relative periodic orbits

Spiral waves are observed in many chemical and biological systems, for example in the Belousov–Zhabotinsky reaction. Rigidly rotating spiral waves are rotating waves and therefore examples of relative equilibria. Meandering spiral waves are periodic in a corotating frame and therefore examples of relative periodic solutions. We study the bundle structure near relative periodic orbits and show that bifurcation from relative periodic solutions can be reduced to bifurcation from isolated periodic solutions. In this way we obtain a systematic approach to the study of local bifurcation from relative periodic orbits.

F. ZANOLIN:

Bifurcation from periodic orbits in perturbed planar Hamiltonian systems

We consider the perturbed planar differential system

$$u' = -J\nabla H(u) + \varepsilon p(\varepsilon, t, u), \qquad (1)$$

where $H : \mathbb{R}^2 \to \mathbb{R}$ is a continuously differentiable function and $p : I_0 \times \mathbb{R} \times \mathbb{R}^2 \to \mathbb{R}^2$ is a Caratheodory function which is T–periodic in the t–variable; $I_0 =]-\varepsilon_0, \varepsilon_0[$ and J is the symplectic matrix in $\mathbb{R}^2$.
We assume the existence of a T–periodic solution $u_0(\cdot)$ of the unperturbed Hamiltonian autonomous equation

$$u' = -J\nabla H(u) \qquad (2)$$

and we look for the existence of T–periodic solutions of (1), which, for ε small, are close to this solution. The same question is addressed to the search of subharmonic solutions as well.
Such kind of problems have already been investigated by a lot of authors. In many papers (among other conditions) it is assumed that H is C^2 and the variational equation

$$v' = -JH''u_0(t))v \qquad (3)$$

is nondegenerate, i.e. the set of its T–periodic solution is one dimensional (equal to $\langle u_0' \rangle$).
In this work we present a result of bifurcation for the perturbed planar Hamiltonian system (1) using elementary topological degree methods. We permit also a non–Hamiltonian perturbation p.

We replace the nondegeneracy condition (3) by a sign condition on the time–map (period–map) of (1) and also a condition on the change of the sign

$$a(s) = \int_0^T \nabla H(u_0(t+s))p(0,t,u_0(t+s))dt.$$

The type of result we can obtain is the following.

Theorem 1. Suppose that (2) has a T–periodic orbit $u_0(\cdot)$ such that the time–map is strictly increasing (or decreasing) at $u_0(\cdot)$ and there exist $s_0, s_1 \in [0,T[$ such that $a(s_o) < 0$ and $a(s_1) > 0$. Then there are two branches of T–periodic solutions of (1) bifurcating from translations in time of the original solution of (2).

More general (even quite 'wild') behaviour of the time–map in its crossing the value T (or T/n, or mT/n in the case of m–th order subharmonics) is permitted. We stress the fact that no condition of non–zero derivative for the time–map at its crossing point or for the function $a(s)$ at its zeros, is required. Some applications are given to a Duffing equation with forcing and damping, to a perturbed Volterra prey–predator system and to the bifurcation of subharmonics close to a homoclinic solution.
This is a joint work with Marc Henrard (Université Catholique de Louvain, Louvain-l-a–Neuve).

BERICHTERSTATTER: H.O. WALTHER (GIESSEN)

Alberto Abbondandolo
abbo@sns.it

Antonio Ambrosetti
ambrosetti@sns.it

Thomas Bartsch
thomas.bartsch@math.uni-giessen.de

Massimiliano Berti
berti@cibs.sns.it

Matthias Büger
matthias.bueger@math.uni-giessen.de

Maria-Christina Ciocci
mcc@cage.rug.ac.be

Mariana Courcelle
courcelle@mathematik.uni-stuttgart.de

Messoud Efendiev
efendiev@math.fu-berlin.de.

Lynn H. Erbe
lerbe@math.unl.eduuniv.edu.kw

Bernold Fiedler
fiedler@math.fu-berlin.de

Alessandro Fonda
fondass@univ.trieste.it

Tomas Gedeon
gedeon@mathfs.math.montana.edu

Vassili Gelfreich
gelf@math.fu-berlin.de

Stephan van Gils
stepahn@math.utwente.nl

Shouchuan Hu
ssh209f@mail.smsu.edu

Christopher Jones
ckrtj@cfm.brown.edu

Hansjörg Kielhöfer
kielhoefer@math.uni-augsburg.de

Klaus Kirchgässner
kirchgaessner@mathematik.uni-stuttgart.de

Urs Kirchgraber
kirchgraber@math.ethz.ch

Jürgen Knobloch
knobloch@mathematik.tu-ilmenau.de

Thomas Kriecherbauer
tkriech@rz.mathematik.uni-muenchen.de

Jaroslav Kurzweil
kurzweil@math.cas.cz

Bernhard Lani–Wayda
Bernhard.Lani-Wayda@math.uni-giessen.de

Reiner Lauterbach
lauterbach@math.uni-hamburg.de

Eric Lombardi
lombardi@inln.cnrs.fr

Stanislaus Maier–Paape
maier@math.uni-augsburg.de

John Mallet–Paret
jmp@cfm.brown.edu

Jean Mawhin
Mawhin@amm.ucl.ac.be

Alexander Mielke
mielke@ifam.uni-hannover.de

Roger D. Nussbaum
nussbaum@fermat.rutgers.edu

Rafael Ortega
rortega@goliat.ugr.es

Carlota Rebelo
carlota@ptmat.lmc.fc.ul.pt

L.E. Rossovksii
skub@k803.mainet.msk.su

Björn Sandstede
sandstede@wias-berlin.de, sansted@cfm.brown.edu

Arnd Scheel
scheel@math.fu-berlin.de

Jürgen Scheurle
scheurle@mathematik.tu-muenchen.de

Klaus Schmitt
schmitt@math.utah.edu

Klaus R. Schneider
schneider@wias-berlin.de

Enrico Serra
serra@polito.it

Alexander L. Skubachevskii
skub@k803.mainet.msk.su

Roman Srzednicki
srzednic@im.uj.edu.pl

Massimo Tarallo
tarallo@vmimat.mat.unimi.it

André Vanderbauwhede
avdb@cage.rug.ab.be

Hans-Otto Walther
hans-otto.walther@math.uni-giessen.de

Michel Willem
willem@amm.ucl.ac.be

Claudia Wulff
wulff@math.fu-berlin.de

Fabio Zanolin
zanolin@dimi.univd.it

Tagungsteilnehmer

Prof.Dr. Alberto Abbondandolo
Scuola Normale Superiore di Pisa
Piazza dei Cavalieri 7

I-56126 Pisa

Prof.Dr. Antonio Ambrosetti
SISSA
via Beirut 4

I-34014 Trieste

Prof.Dr. Thomas Bartsch
Mathematisches Institut
Universität Gießen
Arndtstr. 2

35392 Gießen

Prof.Dr. Massimiliano Berti
Scuola Normale Superiore
Piazza dei Cavalieri, 7

I-56100 Pisa

Dr. Matthias Büger
Mathematisches Institut
Universität Gießen
Arndtstr. 2

35392 Gießen

Prof.Dr. Maria-Cristina Ciocci
Department of Pure Mathematics and
Computer Algebra
University of Gent
Galglaan 2

B-9000 Gent

Dr. Mariana Courcelle
Mathematisches Institut A
Universität Stuttgart
Pfaffenwaldring 57

70569 Stuttgart

Prof.Dr. Messoud Efendiev
Institut für Mathematik I (WE 1)
Freie Universität Berlin
Arnimallee 2-6

14195 Berlin

Prof.Dr. Lynn H. Erbe
Department of Mathematics and
Statistics
University of Nebraska
Lincoln

Nebraska 68588
USA

Prof.Dr. Bernold Fiedler
Institut für Mathematik I (WE 1)
Freie Universität Berlin
Arnimallee 2-6

14195 Berlin

Prof.Dr. Alessandro Fonda
Dipartimento di Scienze Matematiche
Universita di Trieste
Piazzale Europa 1

I-34100 Trieste (TS)

Prof.Dr. Christopher Jones
Division of Applied Mathematics
Brown University
Box F

Providence , RI 02912
USA

Prof.Dr. Tomas Gedeon
Dept. of Mathematical Sciences
Montana State University

Bozeman , MT 59717
USA

Prof.Dr. Hansjörg Kielhöfer
Institut für Mathematik
Universität Augsburg

86135 Augsburg

Prof.Dr. Vassili Gelfreich
Institut für Mathematik I (WE 1)
Freie Universität Berlin
Arnimallee 2-6

14195 Berlin

Prof.Dr. Klaus Kirchgässner
Mathematisches Institut A
Universität Stuttgart
Pfaffenwaldring 57

70569 Stuttgart

Prof.Dr. Stephan van Gils
Department of Applied Mathematics
Twente University
P.O.Box 217

NL-7500 AE Enschede

Prof.Dr. Urs Kirchgraber
Mathematik Departement
ETH Zürich
ETH-Zentrum
Rämistr. 101

CH-8092 Zürich

Prof.Dr. Shouchuan Hu
Dept. of Mathematics
Southwest Missouri State University
901 South National Avenue

Springfield , MO 65804
USA

Dr. Jürgen Knobloch
Institut für Mathematik
Technische Universität Ilmenau
Postfach 100565

98684 Ilmenau

Dr. Thomas Kriecherbauer
Mathematisches Institut
Universität München
Theresienstr. 39

80333 München

Prof.Dr. Jaroslav Kurzweil
Institute of Mathematics of the
AV CR
Zitna 25

115 67 Praha 1
CZECH REPUBLIC

Dr. Bernhard Lani-Wayda
Mathematisches Institut
Universität Gießen
Arndtstr. 2

35392 Gießen

Dr. Reiner Lauterbach
Institut für Angewandte Mathematik
Universität Hamburg
Bundesstr. 55

20146 Hamburg

Dr. Eric Lombardi
I.N.L.N. (CNRS-Universite de Nice)
Sophia-Antipolis
1361, route des Lucioles

F-06560 Valbonne

PD-Dr. Stanislaus Maier-Paape
Institut für Mathematik
Universität Augsburg

86135 Augsburg

Prof.Dr. John Mallet-Paret
Division of Applied Mathematics
Brown University
Box F

Providence , RI 02912
USA

Prof.Dr. Jean Mawhin
Institut de Mathematique
Pures et Appliquee
Universite Catholique de Louvain
Chemin du Cyclotron, 2

B-1348 Louvain-la-Neuve

Prof.Dr. Alexander Mielke
Mathematisches Institut A
Universität Stuttgart
Postfach 801140

70569 Stuttgart

Prof.Dr. Roger D. Nussbaum
Dept. of Math.
Rutgers University
Hill Cener Bldg.
Bush Campus

Piscataway , NJ 08854
USA

Prof.Dr. Rafael Ortega
Departamento de Matematica Aplicada
Universidad de Granada

E-18071 Granada

Prof.Dr. Carlota Rebelo
CMAF & University of Lisboa
Centro de Matematica Aplicacoes
Fundamentais
Av. Prof. Gama Pinto, 2

P-1699 Lisboa Codex

Prof.Dr. Leonid Rossovskii
Dept. of Diff. Equations
Moscow State Aviation Institute
Volokolamskoe sh. 4

Moscow , 125871
RUSSIA

Dr. Björn Sandstede
Dept. of Mathematics
Ohio State University

Columbus , OH 43210
USA

Arnd Scheel
Mathematisches Institut
Freie Universität Berlin
Arnimallee 2 - 6

14195 Berlin

Prof.Dr. Jürgen Scheurle
Zentrum Mathematik
TU München

80290 München

Prof.Dr. Klaus Schmitt
Dept. of Mathematics
University of Utah

Salt Lake City , UT 84112-0090
USA

Prof.Dr. Klaus R. Schneider
Weierstraß-Institut für
Angewandte Analysis und Stochastik
im Forschungsverbund Berlin e.V.
Mohrenstr. 39

10117 Berlin

Prof.Dr. Enrico Serra
Dipartimento di Matematica
Politecnico di Torino
Corso Duca degli Abruzzi, 24

I-10129 Torino

Prof.Dr. Alexander L. Skubachevskii
Dept. of Diff. Equations
Moscow State Aviation Institute
Volokolamskoe sh. 4

Moscow , 125871
RUSSIA

Prof.Dr. Roman Srzednicki
Instytut Matematyki
Uniwersytet Jagiellonski
ul. Reymonta 4

30-059 Krakow
POLAND

Prof.Dr. Massimo Tarallo
Dipartimento di Matematica
Universita di Milano
Via C. Saldini, 50

I-20133 Milano

Prof.Dr. André Vanderbauwhede
Dept. of Pure Mathematics
University of Gent
Krijgslaan 281

B-9000 Gent

Prof.Dr. Hans-Otto Walther
Mathematisches Institut
Universität Gießen
Arndtstr. 2

35392 Gießen

Prof.Dr. Michel Willem
Dept. de Mathematique
Universite Catholique de Louvain
Chemin du Cyclotron 2

B-1348 Louvain-la-Neuve

Claudia Wulff
Institut für Mathematik I (WE 1)
Freie Universität Berlin
Arnimallee 2-6

14195 Berlin

Prof.Dr. Fabio Zanolin
Dipartimento di Matematica e
Informatica
Universita di Udine
Via delle Scienze 206

I-33100 Udine