IP1
Pulse Dynamics in Mode-locked Lasers

Mode-locked lasers produce ultrashort pulses of light. The pulse circulating inside a mode-locked laser experiences the effects of nonlinearity, dispersion and gain/loss. The interplay between these determine the properties of the output pulse train. The development of techniques to track the phase evolution of the pulses is driving efforts to improve the understanding of pulse dynamics in mode-locked lasers. I will present experimental results on characterizing mode-locked lasers and their output pulse train and compare to theoretical results.

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IP2
Enstrophy, Enstrophy Production, and Regularity in the 3D Navier-Stokes Equations

It is still not known whether solutions to the 3D Navier-Stokes equations for incompressible flows in a finite periodic box can become singular in finite time. (This is the subject of one of the $1M Clay Prize problems.) It is known that a solution remains smooth as long as the enstrophy, i.e., the mean-square vorticity, of the solution is finite. The generation rate of enstrophy is given by a functional that can be bounded using elementary functional estimates. Those estimates establish short-time regularity but they do not rule out finite-time singularities. In the original research reported here we formulate and solve a variational problem for the maximal growth rate of enstrophy and display flows that generate enstrophy at the greatest possible rate. Implications of the results for questions of regularity or singularity of the 3D Navier-Stokes equations are discussed. This is joint work with Lu Lu (Wachovia Investments).

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IP3
Swarming by Nature and by Design

The cohesive movement of a biological population is a commonly observed natural phenomenon. With the advent of platforms of unmanned vehicles, this occurrence is attracting renewed interest from the engineering community. This talk will review recent research results on both modeling and analysis of biological swarms and also design ideas for efficient algorithms to control groups of autonomous agents. For biological models we consider two kinds of systems: driven particle systems based on force laws and continuum models based on kinematic rules. Both models involve long-range social attraction and short range dispersal and yield patterns involving clumping, mill vortices, and surface-tension-like effects. For artificial platforms we consider the problem of boundary tracking of an environmental material and consider both computer models and demonstrations on real platforms of robotic vehicles. We also consider the motion of vehicles using artificial potentials.

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IP4
Nonlinear Four-wave Interactions and Freak Waves

Wave forecasting is about forecasting the mean sea state, as reflected by the ocean wave spectrum, and for quite some time it was thought that it was not possible to make statements about extreme events. Recently, however, it has been shown how to relate fluctuations around the mean sea state to the wave spectrum. Therefore, when the wave spectrum is known, the probability distribution function (pdf) of the sea surface elevation can be determined. The tails of the pdf give vital information on the occurrence of extreme events such as freak waves. It is important to try to understand why extreme waves do occur. Nowadays it is accepted that at least three mechanisms are responsible for the formation of extreme waves. The first one is just linear superposition of waves, in this case the surface elevation probability distribution is Gaussian. The second mechanism is the interaction of waves with nonuniform currents, linear theory can explain the formation of extreme waves using ray theory. The third mechanism is regarded by the present author as the most promising mechanism as it may provide an explanation for the formation of freak waves on the open ocean: the generation of extreme events as a result of the modulational instability, a four wave quasi-resonant interaction process. This process will result in deviations from the normal distribution of waves, in particular in the case of long-crested waves which implies almost one-dimensional propagation. Starting from the Hamiltonian description of surface gravity waves it is shown that the short-term dynamics of ocean waves is governed by the Zakharov equation. I have used its one-dimensional version to study the statistical properties of the generation of extreme events using a Monte Carlo simulations. Indeed, deviations from the Normal distribution are shown to be related to the mean sea state. Good agreement with an approximate statistical theory is found, which at the same time describes the evolution in time of the wave spectrum owing to quasi-resonant four wave interactions. In order to better understand the formation of extreme events we study the properties of the narrow-band version of the Zakharov equation, which turns out to be the well-known Nonlinear Schrödinger (NLS) equation. For one-dimensional propagation, the NLS equation may be solved by means of the Inverse Scattering approach and for large times an initial disturbance evolves towards a train of envelope solitary waves, explaining the formation of extreme events. In fact, if the ocean would be truly one-dimensional, shipping would be a hazardous enterprise. In the case of two-dimensional propagation however, envelope solitons are unstable to transverse pertubations and therefore in that event the formation of freak waves is less frequent.

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IP5
Turbulent-laminar Patterns in Plane Couette Flow

The greatest mystery in fluid dynamics is probably transition to turbulence. The simplest shear flow, plane Couette flow – the flow between parallel plates moving at different velocities – is linearly stable for all Reynolds numbers, but nevertheless undergoes sudden transition to 3D turbulence

at Re near 325. At just these Reynolds numbers, it was recently discovered experimentally at CEA-Saclay that the flow takes the form of a steady and regular pattern of alternating wide turbulent and laminar bands, tilted at an angle with respect to the streamwise direction. We have been able to reproduce these remarkable flows in numerical simulations of the Navier-Stokes equations. Simulations display a rich variety of variants of these patterns, including spatio-temporal intermittency, branching and travelling states, and localized states analogous to spots. Quantitative analysis of the Reynolds-averaged equations reveals that both the mean flow and the turbulent force are centrosymmetric and can be described by only three trigonometric functions, leading to a model of 6 ODEs. We find that the transition is best described as a bifurcation in the probability distribution function of the power spectrum.

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IP6

Experiments with Ultracold Atoms in Optical Potentials: Searching for Disorder Induced Effects

We will present recent experiments performed in Florence with the aim to study disorder induced effects using ultracold atoms in optical potentials. Our approach to the realization of a disordered potential is the implementation of a bichromatic quasi-periodic optical lattice. In particular, we will discuss the possibility to observe a Bose Glass phase with strongly interacting bosons and the perspectives to observe Anderson localization with non-interacting or weakly interacting bosons.

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IP7

Reading the Thoughts of a Mollusk: The Neural Origins of Seashell Structure and Pattern

We explain how the simple neurosecretory system of aquatic mollusks is able to generate the diverse array of structures and pigmentation patterns found among their shells. By constructing a mathematical representation of this biological system, we first explain how it gives rise to many distinct shell shapes. Then we shift our focus to the pigmentation control system. We demonstrate how our mathematical model also faithfully reproduces many of the even more diverse pigmentation patterns. The anatomical and physiological basis of this model sets it apart from other mathematical representations of shape and pattern. In addition to explaining the shell construction and patterns, we also predict patterns of shell repair in response to environmentally induced disruptions. The model makes additional predictions about the potential evolutionary relationships between shells with different patterns. Finallly, there are several novel mechanisms for pattern formation suggested by the model. This is joint work with Alistair Boettiger and George Oster.

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CP1

Stability and Propagation of Pulses in Nonlinear Schrodinger Models

Nonlinear Schrodinger equations (NLS) with complex, variable coefficient can model pulse propagation in inhomogeneous media with energy gain or attenuation. Special exact solutions are obtained by first isolating the chirp factor and a variant of the Hirota bilinear method. A competition between linear gain/loss versus their nonlinear counterparts is assessed. For coupled NLS systems, instability will depend on the number of components, and the relative magnitude of the cross and self phase modulation coefficients.

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CP1

Multistable Soliton Solutions in Cubic-quintic Nonlinear Schrdinger Lattices

We study the existence and stability of fundamental discrete solitons in one-, two- and three-dimensional nonlinear Schrödinger lattices with a combination of cubic self-focusing and quintic self-defocusing onsite nonlinearities. Several species of stationary solutions are constructed, and bifurcations linking their families are investigated, starting numerical analysis from the anti-continuum limit, and also with the help of a variational approximation.

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CP1

Thresholds for breather Solutions of the Discrete Nonlinear Schrödinger Equation with Saturable and Power Nonlinearity

Theoretical and numerical results are proved showing that periodic solutions (called breather solutions or discrete solitons) of the Discrete Nonlinear Schrödinger equation with saturable and power nonlinearity satisfy explicit lower bounds on their power. The consideration of limiting cases with respect to the size of the nonlinearity parameters and nonlinearity exponents, demonstrate that these bounds are quite sharp estimates of a threshold value on the power needed for the the existence of a breather solution.

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CP1
Solitons in Schrödinger Lattices with Local Inhomogeneities

We analyze the existence, stability, dynamical formation and mobility properties of localized solutions in systems described by the discrete non–linear Schrödinger equation with a linear point defect. We consider both attractive and repulsive defects in a focusing lattice.

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CP1
Cusp Profiles in Nonlocal Nonlinear Schrdinger Equations

We consider wave dynamics in a nonlocal nonlinear Schrodinger equation. Using a Madelung transformation [E. Madelung, "Quantetheorie in hydrodynamischer form," Zeitshrift fur Physik 40, 322 (1927).], we map the flow first to ideal fluid equations and then to a generalized Camassa-Holm equation [R. Camassa and D.D. Holm, Phys. Rev. Lett. 71, 1661 (1993).]. This latter system is well-known to provide cuspon and peakon solutions. In the Schrodinger case, higher-order terms round the tips but maintain the exponentially-decaying tails. Experimentally, we use spatial optical systems to observe transverse cusp profiles in thermal media with nonlocal nonlinearity.

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CP2
Non-Normal Stability Analysis of a Shear Current under Surface Gravity Waves

The stability of an horizontal shear current under surface gravity waves is investigated on the basis of the Rayleigh equation. As the differential operator is non–normal, a standard modal analysis is not effective in capturing the transient growth of a perturbation. The representation of the stream function by a suitable basis of bi–orthogonal eigenfunctions, allows one to determine the maximum growth rate of a perturbation. It turns out that such a growth rate can be almost two orders of magnitudes larger than the maximum eigenvalue obtained by standard modal analysis.

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CP2
Lagrangian-Averaging Method in the Modeling of Wind-Driven Surface Waves

The Lagrangian-averaged Navier-Stokes-α model was introduced in 1998, as a closure model for computing turbulence. The α-model is the first to use Lagrangian averaging to address the turbulence closure problem. Their modeling scheme uses the mechanism of nonlinear dispersion instead of diffusion, which provides an alternative way to reach turbulence closure without enhancing viscosity. It has been successfully tested and compared with other well-known turbulence models. It, however, has not been utilized much in solving real fluid flow problems. One of the obstacles is in the fact that the α-model requires auxiliary boundary conditions in addition to the conditions satisfying general conservation laws. We illustrate such additional conditions are not feasible in the modeling of sea surface waves generated by winds. We consolidate the Lagrangian-averaging modeling concept and find the alternatives. The results are compared with those obtained by using the models based on the exact Navier-Stokes equations.

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CP2
Wave Propagation in Granular Lattices

A simple setup for the study of nonlinear wave propagation in solids is provided by one-dimensional (1D) granular lattices, which consist of chains of interacting particles that deform elastically when they collide. This system provides an ideal setting to study the interplay between nonlinearity and periodicity. In this talk, I will focus on the propagation of highly nonlinear solitary waves in granular lattice dimers (periodic chains of two different types of beads) using experiments, numerical simulations, and theoretical analysis. My collaborators and I have found excellent agreement between experiments and numerics in a model with Hertzian interactions between adjacent spherical beads, which in turn agrees very well with a theoretical analysis of the model in the long-wavelength regime that we derive for heterogeneous environments and general bead interactions. Our analysis encompasses previously-studied examples as special cases and also provides key insights on the influence of the dimer lattice on the properties (width and propagation speed) of wave solutions of the nonlinear partial differential equation governing the long-wavelength dynamics. I will also discuss more recent results on other granular lattice configurations.

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CP2
Wave Propagation and Pattern Formation for a Reaction-Diffusion System with Nonlinear Diffusion

We investigate the formation of macroscopic spatio-temporal structures (patterns) for a reaction-diffusion system with nonlinear diffusion. We show that cross-diffusion effects are responsible of pattern initiation. Through a weakly nonlinear analysis we are able to predict the shape and the amplitude of the pattern. In the weakly nonlinear regime we derive the Ginzburg-Landau equation which captures the envelope evolution and the progressing of the pattern as a wave. Numerical simulations, performed using both a particle and a spectral method, are in good agree-

ment with the analytical results.

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CP3

An Adaptive Multigrid Scheme for Computing Superfluid Densities of Bose-Einstein Condensates in a Periodic Potential

We present a new implementation of multigrid methods for tracing solution curves of nonlinear elliptic eigenvalue problems. The proposed algorithm is a generalization of the two-grid discretization schemes described in [**?**], which can be flexibly implemented. More precisely, the approximating points we wish to compute do not necessarily lie on the same grid. The algorithm can be very efficient whenever it is combined with high order discretization methods. We apply the proposed algorithm to compute energy levels and superfluid densities of Bose-Einstein condensates (BEC) in a periodic potential. For chemical potential large enough, our numerical results show that the number of peaks of the 2D BEC in a periodic potential is completely determined by the wave number of the periodic potential if the domain is properly chosen. Moreover, the number of peaks is $(\frac{1}{d}-1)^2$, where d is the distance of neighbor wells. The numerical results are consistent with the mathematical formulation of the BEC in a periodic potential.

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CP3

Transition to Turbulence in Bose-Einstein Condensate Through Bending-Wave Instability of a Single Vortex Ring

A vortex ring solution with small bending-wave perturbation is achieved in Bose-Einstein condensate and serves as an initial condition of the time-dependent GrossPitaevskii equation to explore the dynamics of perturbed vortex ring. The result shows that the perturbation of vortex ring first grows into hairpins. As the disturbance is further amplified, vortex re-connection happens. The vortex ring then tangles and breaks into multiple vortex filaments, which eventually develops superfluid turbulence in BEC with a Kolmogorov energy spectrum.

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CP3

Motion of Quantum Vortices on Inhomogeneous Backgrounds

The motion of quantized vortices on two-dimensional inhomogeneous density backgrounds with boundaries is considered. A Hamiltonian group relation together with the method of images and an approximation for the density background are useful to understand vortex motion. The vortex moves predominantly due to an image vortex near the condensate center and mostly due to a large background density gradient near the boundary. The vortex velocity depends on the global shape of the condensate.

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CP4

Exact Solutions for Some Nonlinear Fractional Parabolic Partial Differential Equations

A method for solving some nonlinear fractional parabolic partial differential equations is considered. Using this method , exact solutions are obtained. By introducing suitable transformation , we obtain a system of fractional ordinary differential equations. This system will generate the exact solutions for the considered nonlinear fractional partial differential equations. The traveling wave solutions are obtained.The efficiency of the considered method can be demonstrated for a large variety of equations , which are more general than Burgers , Murrary and Fishers equations.

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CP4

Nonlinear Scattering by Small Barrier Potentials

Scattering by a barrier potential is a fundamental problem in wave physics, involving issues of boundary conditions, resonances, radiation, etc. While scattering in the linear case is well-known, the nonlinear case has received far less attention. Here, we consider tunneling dynamics in a self-defocusing (repulsive) nonlinear Schrdinger equation. Theoretically, we observe shock-assisted tunneling in 1D and vortex generation in 2D. Experimentally, we demonstrate these effects optically by considering plane-wave scattering in a nonlinear photorefractive crystal.

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CP4

New Integrable System in Nonlinear Elasticity

We introduce a system of evolution PDEs that model a 3D axisymmetric motion for a class of nonlinear elastic materials. We termed the system TIE (**T**wist **I**nflation/deflation **E**longation/contraction). It is shown that TIE is C-integrable via appropriate change of variables. It transforms into a pair of decoupled linear telegraphy equations. The original form of TIE system is somewhat similar to a classic Lund-Pohlmeyer-Regge model in high energy physics. We use this similarity to find a Lax pair for TIE, derive a new simpler form for LPR system, and construct a one-parametric family of new S-integrable systems of PDEs.

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CP4
Simulation of High-Speed Ferry Wakes in Tallinn Bay

Spatial patterns and far field properties of the long-wave part of high-speed ferry wakes in Tallinn Bay are analyzed with use of a Boussinesq-type shallow water model forced by realistic ship motions. Calculated heights of ship waves exhibit substantial spatial variability. Wave impact on the coast line can be related different speed regimes, with the largest waves being generated during deceleration from a supercritical regime (depth Froude number > 1).

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CP4
A New Multi-Component Kp Hierarchy

Multi-component generalizations of KP hierarchy attract a lot of interest from both physical and mathematical points of view. We propose a new multi-component KP (mcKP) hierarchy which includes two kinds of KP equation with self-consistent sources. This hierarchy also admits reductions to the well-known k-constrained KP hierarchy, which contains second type of soliton equation with self-consistent sources, and n-reduced KP hierarchy with self-consistent sources i.e. Gelfand-Dickey hierarchy with self-consistent sources. So the new mcKP hierarchy provides more general approach to find the soliton equations with self-consistent soiurces and their Lax representations.

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CP5
A Spin-Glass Model for Mode-Locking Processes in Random Lasers

We report on a theoretical model concerning the nonlinear interaction of electromagnetic modes in a random dielectric displaying a laser action. We show that under suitable hypotheses the relevant Hamiltonian can be mapped in a system that can be analysed by the methods of spin-glass physics. A phase-diagram for mode-locking processes in terms of disorder and pumping rate is given.

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CP5
Coupled Mode Equations for Gap Solitons in the 2D Periodic Schroedinger Equation

We derive the coupled mode asymptotics for gap solitons with frequencies in band gaps near band edges in the 2D cubically nonlinear periodic Schroedinger equation. The periodic potential is of finite contrast and both the case of the separable potential $V(x, y) = W(x) + W(y)$ and a general nonseparable periodic potential are discussed. We rigorously justify coupled mode equations for the envelopes around the specific number of Bloch modes resonant at the band edge. The analysis is performed in the Bloch space and uses a Liapunov-Schmidt reduction. Various gap solitons including vortices are also computed numerically.

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CP5
Effect of Dispersion on Gap Solitons

The Nonlinear Coupled Mode Equations (NLCME) are the envelope equations currently used to describe light propagation in fiber Bragg gratings and Bose-Einstein condensates in optical lattices. It has been recently shown that dispersive terms have to be added to the NLCME in order to correctly describe the dynamics of the system. The effect of dispersion drastically changes the stability of the uniform states (aka Continuous Waves) and gives rise to new complex spatio temporal dynamics that are not included in the NLCME. In this talk we review this new dispersion induced dynamics, and show that the Gap Solitons, on the contrary, are not destabilized by dispersion.

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CP5

Gap Solitons in Gratings with Random Parameters

The dynamics of gap solitons in gratings with a random variation of the bandgap is studied theoretically. It is found that the soliton can be trapped by the grating inhomogeneity. It is shown that the soliton self-averages the fluctuations of the random grating, smoothing the high-wavenumber components of the noise. The correlation function of the force acting on the gap soliton, as well the statistical properties of the soliton parameters are found.

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CP6

Third Order Calculations for Wavegroup Evolutions

The AB-equation (Van Groesen and Andonowati 2007) has shown to be an accurate model to simulate the evolution of various types of waves and wavegroups. We show results of third-order approximations of the detailed evolution and of global properties such as the MTA (Maximal Temporal Envelope), of highly distorting bichromatic wavegroups. Results are compared with experiments and numerical AB-simulations.

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CP6

Long Range Solution of the Wave Equation Using Nonlinear Solitary Waves

A new method is described to compute long range pulse solutions to the linear wave equation on a uniform grid. Unlike conventional Eulerian solutions, these waves remain narrow, several grid cells (h) in width, and do not spread due to discretization error even over indefinite distances. These pulses represent a traveling wave front as a codimension 1 surface and accurately represent the total amplitude and arrival time of a pulse in one or three dimensions.

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CP6

Nonlinear Schrdinger Solitons with Non-Zero Velocities Emerging from Real Symmetric Initial Conditions.

Real symmetric initial conditions in the NLS equation have long been considered to create only zero-velocity solitons. We show, using an approximate solution of the concomitant Zakharov-Shabat eigenvalue problem, that this result is not an intrinsic feature of the NLS equation. In particular, two separated sech-pulses are shown, under certain conditions, to give rise to separating solitons.

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CP6

Free Energy Metamorphosis and Critical Phenomena in Soliton Gases

We investigate the dynamics of a gas of soliton wave-particles. We demonstrate that the system exhibits phase transitions in term of shock waves. This is predicted by exactly solving the nonlinear equations and by employing methods of the statistical mechanics of chaos. In particular, we show that a suitable free energy undergoes a metamorphosis thereby developing a phase transition. This demonstrates that even the simplest phase-space, made by noninteracting particles, sustains critical phenomena.

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CP7

Ab-Initio Simulation of Anderson Localization and Lasing in Disordered Photonic Crystals

We report on 3D time-domain parallel simulations of dynamic light diffusion and localization in inverted disordered opals displaying a complete photonic band-gap. The Maxwell-Bloch equations for a four level system are solved in 3D and in the time-domain. The transition from delocalized Bloch modes to Anderson localization in lasing processes in disordered inverted opals filled by an active medium is investigated.

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CP7

Control and Interaction of Excitable Localized Structures in Kerr Media

Localized structures (LS) in extended media may develop a number of instabilities like start moving, breathing, or oscillating. In Kerr cavities there is a route in which autonomous oscillons (oscillating LS) become excitable. We study the effect of introducing an addressing beam which allows to control the properties of this excitable LS. We also study the interaction of two LS, both in the oscillatory and in the excitable regimes.

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CP7

Dynamical Instabilities of Localized Structures in Nonlinear Optical Cavities with Metamaterials

We characterize the instabilities in parameter space of Localized Structures in a Kerr cavity containing a metamaterial, described by the Lugiato-Lefever (LL) with an extra bilaplacian term. The behavior of the system is organized by two Takens-Bogdanov points of opposite stability. The system exhibits tristability and two excitability regimes: in one of them, conditional excitability, the system is both bistable and excitable. The results are compared with the LL equation, with an asymptotic Takens-Bogdanov point.

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CP7

Waves, Coherent Structures and Spatiotemporal Complexity in the Electroconvection of Nematic Liquid Crystals

We present a study of the nonlinear physical mechanisms generating the waves observable near onset of nematic electroconvection, in the case of Hopf bifurcation to oblique traveling rolls. Globally coupled Ginzburg Landau equations, with coefficients computed from the weak electrolyte model for I52, are used to describe the dynamics. We find a rich variety of oblique waves, as well as complex spatiotemporal structures, including spatiotemporal chaos dominated by holes, dislocations, phase slips and grain boundaries.

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CP8

Bifurcations of Nonlinear Defect Modes

The nonlinear coupled mode equations describe the evolution of light in Bragg grating optical fibers. Defects (localized potentials) can be added to the fiber in order to trap light at a specialized location as a nonlinear defect mode. We consider symmetry-breaking bifurcations of these modes via numerics and the derivation of normal-mode equations for the bifurcation. Time permitting, we will discuss the design of defects, Hopf bifurcations, and comparison with similar problems in NLS.

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CP8

On the Analytical Treatment of Modulated Wavepackets in Nonlinear Dispersive Continuous Media

The methodology employed in modelling of the self-modulation of waves propagating in nonlinear dispersive

media is discussed, from first principles. Considering the paradigm a nonlinear Klein- Gordon equation with an asymmetric nonlinear substrate potential, two established methods for the derivation of an evolution equation for the waves amplitude (the wave packets envelope), namely a nonlinear Schrodinger-type (NLS) equation, are reviewed and discussed. Although the anticipated result is qualitatively recovered, the two methods (namely, a Taylor expansion of the nonlinear dispersion relation, on one hand, and the reductive perturbation - multiple scales - technique, on the other) are shown to lead to different results, in the case considered (thus not excluding others). A qualitative discussion leads to the conclusion that particular caution and care in the underlying physical assumptions are imposed, when one undertakes a study of modulation-related nonlinear phenomena associated to nonlinear wave propagation.

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CP8

Nonlinear Waves in Multilayer Systems

The joint action of buoyancy and the thermocapillary effect in multilayer systems for two different variants of heating: (a) when heating is from below, and (b) when a temperature gradient is directed along the interfaces, is investigated. Regimes of nonlinear traveling waves, are observed. The transient process from the unicell structure into the multicell structure, is studied. Some new phenomena which arise as a result of the interaction between different interfaces, are discussed (Nepomnyashchy A., Simanovskii I., Legros J.-C., Interfacial Convection in Multilayer Systems, Springer, New York, 2006).

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CP9

Dynamics of Solitary Gravity-Capillary Waves on Infinite Depth

Model equations for gravity-capillary waves on a three dimensional fluid of infinite depth are proposed. Branches of solitary waves are computed in each model equation. The stability of each branch of waves is discussed. The time dependent evolution of unstable waves is observed. Stable waves from each branch are collided, including both head-on and overtaking collisions.

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CP9

Exact Solutions of An Equation Modelling Blood Flow in Arteries

The derivation of exact solutions for a partial differential equation modelling arterial deformation in large arteries is considered. We use the Lie symmetry method and find that, amongst others, the equation admits a reduction to the first Painlevé equation. The asymtotic approximation of the equation to the Korteweg-de Vries equation is also considered, which provides a connection with the second Painlevé equation. We thus give a further demonstration of the applicability of the Painlevé equations.

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CP9

Mean Flow Effects in the 1:3 Faraday Wave Internal Resonance

We consider the effect of mean flow in the subharmonic 1:3 internal resonance. We derive equations for the coupled evolution of the wave amplitudes and the mean flow which describe the evolution of spatially uniform Faraday waves produced in a vertically vibrated container. We focus on the case of small viscosity and deep fluid layer with surface contamination. The coupled amplitude–mean flow equations are numerically integrated to show that the presence of the mean flow changes radically the dynamics near the 1:3 resonance point.

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CP10

The Condition Number of the Sn Transport Matrices

We describe the conditioning of the $Nodal\ LTS_N$ matrix in order to solve a three-dimensional discrete ordinates problem. The $LTS_N - DiagExp$ method consists in the application of the Laplace transform to the set of nodal S_N equations and solution of the resulting linear system. The transverse leakage terms are represented by exponential functions with decay constants that depend on the characteristics of the material of the medium the particles leave behind.

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CP10

Streaky 3D Structures in the Boundary Layer

It has been recently shown [Choi, Nature, April 06 - Cossu, PRL, February 06] that 3D streak structures in the boundary layer can remain laminar longer than the 2D Blasius flow. The aim of this investigation is to study the possibility of promoting these 3D streaky structures via surface roughness, computing them and evaluating the resulting stabilization using the Reduced Navier Stokes equations (RNS). The RNS are derived from Navier-Stokes making use of the fact that two very different scales are present: one slow (streamwise direction) and two short (spanwise and wall-normal direction). The RNS allows us to perform these 3D computations in a standard PC, whithout using CPU costly DNS simulations.

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CP11

Orbital Stability of Solitary Waves for Three Coupled Long Wave-Short Wave Interaction Equations

We consider a three component system of one dimensional long wave-short wave interaction equations

$$\begin{aligned} &i\phi_t + \alpha\phi_{xx} = \beta u\phi, \\ &i\psi_t + \alpha\psi_{xx} = \beta u\psi, \\ &u_t = \beta(|\phi|^2 + |\psi|^2)_x, \end{aligned} \qquad (1)$$

where u is a real-valued long wave mode and ϕ and ψ are the complex-valued short wave modes. This system has been derived to describe the resonant wave propagation, [ADD Craik, Wave interactions and fluid flows, Cambridge University Press, 1985], [S Erbay, Chaos, Solitons and Fractals, 11, 1789-1798, 2000]. The aim of this study is to show orbital stability of solitary wave solutions for system (1). The proof is based on adapting the method used by Weinstein [MI Weinstein, Comm. Pure and Appl. Math. XXXIX, 51-68, 1986.] for the nonlinear Schrödinger equation and by Laurençot [PH Laurencot, Nonlinear Analysis, TMA, 24, 509-527, 1995]for a two component long wave-short wave resonant system. It is proved that the solitary wave solutions of system (1) are orbitally stable in $H^1(\mathbb{R}) \times \mathrm{H}^1(\mathbb{R}) \times \mathrm{L}^2(\mathbb{R})$.

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CP11

Wave-Wave Regular Interactions of a Gasdynamic Type: a Comparison Between Two Geometrical Prospects

Two concurrent geometrical approaches [a genuinely nonlinear and "algebraic" one (Burnat) and, respectively, a "differential" one (Martin)] are used to characterise wave-wave regular interactions [unsteady one-dimensional, steady two-dimensional] of a gasdynamic type – essential ingredients to constructing some nonlinear coherent structures in atmospheric modelling. Some comparable and significant details of the two associated prospects are identified. A "nonalgebraic" character to an *anisentropic* description and, respectively, an "algebraic" character to an *isentropic* description are particularly proven.

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CP11

Non-Existence of Solitary Waves for the Two-Dimensional Long-Wave-Short-Wave Interaction Equations

In this study we establish non-existence of localized solitary waves for the two-dimensional long-wave-short-wave interaction (LSI) equations:

$$\begin{aligned} &i\phi_t + \phi_{xx} = \phi u_x, \\ &u_{tx} + u_{yy} = -(|\phi|^2)_x \end{aligned}$$

where $\phi(x, y, t)$ is a complex-valued function, $u(x, y, t)$ is real, $(x, y) \in \mathbb{R}^2$ and $t \geq 0$. These equations describe the interaction between high-frequency and low-frequency waves near the long-wave short-wave resonance where the group velocity of high-frequency waves is equal to the phase velocity of low-frequency waves. The LSI equations arise in various contexts [Sulem C, Sulem P L, *The Nonlinear Schrodinger Equation: Self Focusing and Wave Collapse*, New York, Springer (1999)], [Colin T D, Lannes D, Long-wave Short-wave Resonance for Nonlinear Geometric Optics, *Duke Math J* **107** 351-419 (2001)]. We prove that there is no nontrivial solution of the LSI equations in the form

$$\begin{aligned} &\phi = e^{i[\omega t + c(x-ct)/2]}\Phi(x - ct, y) \\ &u = U(x - ct, y) \end{aligned}$$

where $\omega \in \mathbb{R}$, $c \in \mathbb{R}$, $\Phi \in H^1(\mathbb{R}^2)$ and $\nabla U \in L^2(\mathbb{R}^2)$. The proof is based on Pohozaev-type identities.

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CP11

Exact Solutions of Some Nonlinear and Coupled Diffusion-Reaction Equations: Viability of Auxiliary Equation Method

Exact solutions of a nonlinear differential equation, if become available, then they have several advantages over the corresponding numerical solutions, particularly with reference to the parametric dependence of the solutions. In the present work, we employ, the auxiliary equation methods, perhaps for the first time, to obtain the exact solutions in two cases; firstly of a class of diffusion-reaction (D-R) equations with polynomial nonlinearities and with a nonlinear convective flux term, and secondly of a pair of coupled nonlinear D-R equations. A detailed analysis of the solutions

so obtained is carried out with an eye on the applications in population dynamics and pattern formation.

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CP13

Tri-Stability in a Pendula Chain

Different Stationary states of boundary driven coupled pendula chain has been investigated experimentally, numerically and analytically. The analytical treatment is based on the boundary driven sine-Gordon equation and it is found that for the same driving force three completely different regimes coexist: Besides two regimes discovered earlier there exists a third regime corresponding to the kink motion in the restricted geometry of the chain. This is confirmed by direct laboratory experiments and Numerical simulations.

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CP13

Existence and Stability of Localized Structures in Hexagonal and Honeycomb Lattices

We examine the existence and the stability properties of single-site, multi-site as well as vortex breathers in a hexagonal and a honeycomb lattice. The first lattice describes a 2D dusty plasma crystal while the second is associated with the optical propagation of beams in optically induced lattices in photorefractive crystals. The two lattices are studied using both Klein-Gordon as well as Discrete Nonlinear Shrodinger models. The two methods are compared and their results are in very close agreement.

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CP13

Stability of Multi-Bump, Blowup Solutions of the Ginzburg-Landau Equation

In this talk we study the stability of radially symmetric blowup solutions of the Ginzburg-Landau equation. Upon writing the Ginzburg-Landau equation as a small perturbation of the nonlinear Schrödinger equation, the existence of multi-bump blowup solutions, especially of ring-like solutions, has already been established. I will give the numerical and analytical results that were obtained. So far, the stability of these blowup solutions had only been examined numerically. We use Evans function techniques developed for perturbations of Hamiltonian systems to study the stability of the ring-type solutions.

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CP13

Numerical Computation of Unstable Manifolds of Stationary Pulses in the Gray-Scott Model

We consider a reaction-diffusion system of partial differential equations (PDEs) called Gray-Scott model and numerically compute the unstable manifolds of stationary pulses. We first reduce the system to ordinary differential equations (ODEs) using a standard finite-difference scheme, and approximate stationary pulses by homoclinic orbits of a four-dimensional map. The homoclinic orbits are computed by the standard computation tool AUTO97 with a driver named "HomMap", and compared with numerical results by a direct application of AUTO97 (HomCont) to ODEs governing stationary solutions of the original PDEs. We finally compute the unstable manifolds of the pulse as the unstable manifolds of equilibria, corresponding to the homoclinic orbits of the map, in a higher- (170 in our computation!) dimensional system of ODEs. Numerical results for one- and three-dimensional unstable manifolds are given and discussed.

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CP14

Theoretical and experimental studies of the evolution of nonlinear surface wave packets

We study the propagation and interaction of nonlinear surface wave packets by solving a set of nonlinear evolution equations for the free surface elevation and the free surface velocity potential numerically using a pseudo-spectral method. Both regular and irregular wave fields are considered and our numerical solutions are validated with new laboratory experiments. Validity of asymptotic models such as the NLS and higher-order NLS equations is also discussed.

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CP14

Parabolic Similarity Solutions of the Nonlinear Schrodinger and Wigner-Moyal Equations

Propagation of partially coherent light in nonlinear Kerr media, as described by the Nonlinear Schrodinger and Wigner-Moyal equations, has recently attracted strong interest. We have found that these equations possess a class of exact self-similar solutions with parabolic intensity profile for arbitrary degrees of coherence. We further show that these solutions can be reduced to a previously known approximate parabolic solution of the Nonlinear Schrodinger equation in the limit of coherent waves.

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CP14

Internal Waves of Permanent Form in Non-Boussinesq Flow

Internal waves in a continuously stratified flow with constant Brunt-Vaisala frequency and zero background velocity are considered. Previous non-Boussinesq treatment of waves that fill the domain [Thorpe (1968) and Yih (1974)] used rigid horizontal boundaries and a straightforward expansion in wave amplitude. When the rigid top is removed, this expansion is not uniformly valid. A different expansion has been found that corrects this problem, and allows determination of the second-order wavespeed and wave-induced mean flow.

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CP14

Dispersive Properties of Multisymplectic Integrators

Multisymplectic (MS) integrators, i.e. numerical schemes which exactly preserve a discrete space-time symplectic structure, are a new class of structure preserving algorithms for solving Hamiltonian PDEs. In this talk we examine the dispersive properties of MS integrators for the linear wave and sine-Gordon equations. In particular a leap frog in space and time scheme (a member of the Lobatto Runge Kutta family of methods) and the Preissman box scheme are considered. We find the numerical dispersion relations are monotonic and that the sign of the group velocity is preserved. The group velocity dispersion (GVD) is found to provide significant information and succinctly explain the qualitative differences in the numerical solutions obtained with the different schemes. Further, the numerical dispersion relations for the linearized sine-Gordon equation provides information on the ability of the MS integrators to capture the sine-Gordon dynamics. We are able to link the numerical dispersion relations to the total energy of the various methods, thus providing information on the coarse grid behavior of MS integrators in the nonlinear regime.

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MS1

Directly and Parametrically Driven Wobbling Kinks in the Dissipative ϕ^4 Theory

We construct the resonantly driven wobbling kink of the ϕ^4 equation. We confirm that the strongest resonance in the case of parametric driving occurs when the driving frequency equals the natural wobbling frequency, and provide a qualitative explanation for this atypical behaviour. For direct driving, we confirm the existence of the superharmonic resonance at half the natural frequency, and show that a weaker resonance at the natural frequency itself does exist, contrary to recent claims.

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MS1

Localised 2D Patterns

We give a review of localised patterns observed in experiments and recent mathematical results concerning these structures. We show that the "snakes and ladders" bifurcation structure of localised patterns (Burke and Knobloch 2007) can be predicted completely from the bifurcation structure of fronts that connect the trivial state to rolls. The results presented here apply to 2D stationary states that are localised in one spatial direction.

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MS1

Exploring the Phase Space of Localized Spikes on a Magnetic Liquid Layer

Two-dimensional localized states have been observed on the surface of a ferrofluid in the bistable regime of the Rosensweig instability (Phys. Rev. Lett. **94**, 2005). These "ferrosolitons" can be generated by a local perturbation B_p of the homogeneous magnetic induction B_H, utilizing a magnetic probe coil. Here we are exploring the minimum values B_p vs. B_H for the generation of ferrosolitons and describe the experimental findings by amplitude equations. Moreover we extract the growth rate of ferrosolitons in (B_p, B_H) from time resolved measurements, utilizing a high speed camera, and compare them with theoretical predictions.

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MS1

Isolas of Multi-pulse Solutions

In the 1-dimensional Swift-Hohenberg equation, localised roll structures have been found to lie on snaking curves, along which infinitely many fold bifurcations occur, with the corresponding solutions developing more and more oscillations about their centre. Recently an analytical approach, yielding a complete description of this snaking scenario for 1-pulse solutions, has been developed. Following this we analyse the behaviour of 2-pulse solutions, which are found to lie on isolas in the bifurcation diagram.

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MS2

Mode-locking Dynamics: Attracting States, Limit Cycles, and Bifurcations

A theoretical model is developed for characterizing mode-locking behavior using a variational method. Fundamental in driving the laser dynamics is the experimentally verified nontrivial phase profiles. These dynamics are combined with discrete components of the mode-locked laser which are responsible for large intra-cavity pulse fluctuations. The reduced models characterize the stable mode-locking by exhibiting underlying stable nodes, spirals, and limits cycles, providing an excellent theoretical framework for understanding and optimizing laser performance.

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MS2

Novel Ultrafast Semiconductor Lasers Based on Surface Emitting Lasers

For diode-pumped solid-state lasers Q-swiching instabilities become more severe as pulse repetition rates increase, but novel low saturation fluence SESAM designs have allowed for pulse repetition as high as 160 GHz at the center wavelength of 1 m, and 80 GHz around 1.5 m. These lasers exhibit excellent performance with quantum noise limited timing jitter and frequency combs with very high optical signal-to-noise ratios. This work also motivated a new approach for passively modelocked semiconductor lasers, replacing the ion-doped solid-state laser with a vertical external cavity surface emitting laser (VECSEL), which has generated picosecond pulses with more than 2 W of average output power. SESAM modelocked optically pumped VECSELs support further integration of gain and saturable absorber within one wafer and ultimately electrical pumping. Such modelocked integrated external-cavity surface emitting lasers (MIXSELs) may offer a new ultrafast laser technology that is scalable between 10 and 100 GHz and enable new applications where todays ultrafast lasers are considered too bulky and expensive.

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MS2

Self-Similar Mode-Locked Lasers

A theoretical model is developed to quantify the experimental observations of self-similar parabolic pulses in a mode-locked laser cavity with net zero-dispersion. The averaging procedure used shows the pulse amplitude to be governed by the porous media equation which has the well-known Barenblatt similarity (parabolic) solution, suggesting it is a viable theoretical description of temporal profiles. This is the first analytic model proposing a mechanism responsible for generating temporal parabolic pulses.

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MS2

Ultra-broadband Vertical External Cavity Semiconductor Laser Simulator

Vertical external cavity semiconductor lasers have emerged as the first high-power, high brightness semiconductor laser devices capable of delivering tens of Watts of power in a TEM00 beam. These structures essentially consist of a two-mirror cavity where one (active) mirror is controlled by an external high-power incoherent diode bar pump. In this talk, I will present an ultra-broadband simulation approach that captures the spatio-temporal dynamics of the VECSEL over its full operating spectral range. The simulation is built on rigorous microscopically computed semiconductor optical properties and will be applied to a study of VECSEL mode-locking using synchronously-pumped and saturable absorber mirror geometries.

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MS3

Noise Effects in the Synchronization of Neuronal Media

Abstract not available at time of publication.

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MS3

Stochastic Travelling Waves

We examine a numerical technique to compute stochastic travelling waves with reference to a fixed profile. We essentially freeze the wave in the domain. The resulting systems means we solve for an 'instantaneous' wave speed. We consider the choice of the fixed profile on the method and compare results to standard computations where the wave moves and reexamine results in the literature. To illustrate the method we examine travelling waves in a neural system.

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MS3

Stochastic Dynamics of Kinks

Localised coherent structures are a striking feature of noisy, nonlinear, spatially-extended systems. In one space dimension with local bistability, coherent structures are kinks. At late times, a steady-state density is dynamically maintained: kinks are nucleated in pairs, diffuse and annihilate on collision. Long-term averages can be calculated using the transfer-integral method, giving exact results that can be compared with large-scale numerical solutions of SPDE. Diffusion-limited reaction is the name given to a reduced model of the dynamics, in which kinks are treated as point particles. Some quantities, such as the mean number of particles per unit length, can be calculated exactly.

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MS3

Waves in Excitable Media with Noise

We look at how waves are nucleated by additive noise in a PDE model of spirla waves in excitable media.

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MS4

Stability of Periodic Travelling Waves Solutions to the Benjamin-Ono Equation

In this talk we establish a novel argument to obtain the stability of a family of periodic travelling wave solutions for the Benjamin-Ono equation (BO)

$$u_t + uu_x - \mathcal{H}u_{xx} = 0,$$

where $\mathcal{H}$ denotes the periodic Hilbert transform defined by

$$\mathcal{H}f(x) = \frac{1}{2L} p.v. \int_{-L}^{L} \cot\left[\frac{\pi(x-y)}{2L}\right] f(y)dy.$$

The associated periodic traveling waves for (BO) with a minimal period $2L$ are given for $c > \pi/L$ as

$$\varphi_c(x) = \frac{2\pi}{L} \frac{(\gamma)}{\cosh(\gamma) - \cos(\frac{\pi x}{L})},$$

such that $\gamma > 0$ satisfies $\tanh(\gamma) = \pi/cL$. The results in this talk are joint work with Fabio Amorin Natali (IME-USP/Brazil).

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MS4

Stability of Plane-wave Solutions of a Dissipative Generalization of the Nonlinear Schrödinger Equation

The modulational instability of perturbed plane-wave solutions of the cubic nonlinear Schrödinger (NLS) equation is examined in the presence of three forms of dissipation. We present three families of decreasing-in-magnitude plane-wave solutions to this dissipative NLS equation. We establish that all such solutions that have no spatial dependence are linearly stable, though some perturbations may grow a finite amount. Further, we establish that all such solutions that have spatial dependence are linearly unstable if a certain form of dissipation is present.

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MS4

Stability of Periodic Waves in Hamiltonian Systems

We discuss the stability of periodic travelling waves in two dispersive models arising in water wave theory: the Kawahara equation and the generalized Korteweg-de Vries equation. While the question of nonlinear stability can be answered for perturbations which have the same period as the original wave, for more general perturbations, including localized perturbations, stability results for such models concern so far the spectral stability. We show how the Hamiltonian structure of these equations can be exploited in order to obtain a complete description of the spectrum of the linearization of the equation at the periodic wave, which then yields the spectral (in)stability for bounded and localized perturbations.

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MS4

On the Pattern of Wind Wave Evolution Subject to Abrupt Change of Wind

Random wave fields can exhibit regular patterns of evolution of ensemble averaged quantities. The cornerstone of the established view of the wind wave evolution is that it occurs on the kinetic ($O(\epsilon^{-4})$ timescale, where ϵ is the characteristic wave steepness, and is governed by the kinetic (Hasselmann) equation. Here we challenge this paradigm by demonstrating both experimentally and by direct numerical simulations (DNS) that when wind changes abruptly the wave field spectra evolve on the dynamic (ϵ^{-2}) timescale. An abrupt increase of wind causes a fast increase of dominant wave steepness and energy and rapid propagation of the disturbance from high-frequency part of the spectrum to the peak. The evolution of kurtosis also occurs on the same fast timescale. This phenomenon cannot be described by the existing models based upon the classical kinetic equation. We derive a generalised kinetic equation able to describe field evolution both on the dynamic and kinetic timescales

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MS5

Bifurcations of Discrete Breathers in Nonlinear Lattices

We will review some mathematical techniques which allow to study the bifurcations of discrete breathers in nonlinear lattices, and apply these techniques to a discrete Klein-Gordon equation.

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MS5

On the Analysis of Travelling Waves in Hamiltonian Lattices

Abstract not available at time of publication.

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MS5

Energy Propagation in Disordered Nonlinear Chains

The joint effect of disorder and nonlinearity on energy transport is still poorly understood. We present some numerical results on propagation of energy in chain of nonlinear oscillators with disorder. Two types of perturbation are considered, either an external periodic driving or an initally localized kick. The existence of transmission thresholds is highlighted.

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MS5

Spectral Theory and Decay Estimates for Dnls in One Spatial Dimension

We consider the 1 D DNLS,$i\partial_t u_n + (u_{n+1} - 2u_n + u_{n-1}) + V_n u_n = F_n(u)$. Similar to the continuous case, we are able to establish for the Hamiltonian $-\Delta_1 + V$ limited absorption principle,Puisseux expansions at zero and related information regarding the spectral behavior. This all generalizes recent work of Komech-Kopylova-Kunze, but we impose only standard (and mild) decay assumptions on V. As a consequence, decay estimates in various function spaces are derived, which in turn will be helpful for asymptotic stability/instability results.

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MS6

Generation of Undular Bores and Solitary Wave Trains in Fully Nonlinear Shallow-water Theory

We review our recent results on the analytic description of large amplitude undular bores and solitary wave trains in fully nonlinear shallow water flows as modeled by the nonintegrable Su-Gardner system of equations (the onedomensional version of the Green-Naghdi equations). The full set of transition condition across the undular bore is obtained using the Whitham modulation theory. For problems with spatially localised initial conditions, we derive an asymptotic formula for the amplitude distribution in a solitary wave train which is formed as the long-time outcome. Excellent agreement with full numerical solutions of the

Su-Gardner system is demonstrated.

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MS6

Whitham Equations for Perturbed Integrable Equations: Applications to Fluid Dynamics

The method of derivation of the Whitham modulation equations for perturbed integrable equations described by the Ablowitz-Kaup-Newell-Segur scheme or equivalent second order spectral problem is developed. The perturbation term can depend on space and time variables as well as on the field variables and their space derivatives. Correspondingly, the resulting Whitham equations contain the perturbation terms which can be expressed in the most important one-phase case as simple integrals convenient for the study in concrete applications. The theory is illustrated by the examples of the perturbed Korteweg-de Vries euqtion, perturbed nonlinear Schroedinger equations and perturbed Kaup-Boussinesq system which have fluid dynamics applications. Formation of undular bores (dispersive shocks) described by these equations is discussed for situations when dissipation and bottom slope can play essential role.

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MS6

Which Wind Model to Use Over Steep Gravity Wave Groups Due to Focusing Mechanisms?

Wind action on wave groups is investigated numerically using the fully nonlinear equations. A steep wave is generated by means of dispersive focusing. First, the wave amplification is due to Miles' mechanism. A comparison with the linear solution of the problem emphasizes the role of nonlinearity on wave focusing in presence of wind. Then, a different mechanism, the modified Jeffreys' sheltering theory, is used. It is found that the wave group persistence is significantly increased when using the latter mechanism.

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MS6

Can Bottom Friction Suppress Freak Waves'?

The paper examines the effect of the bottom stress on the weakly nonlinear evolution of a narrow-band wave field, as a potential mechanism of suppression of 'freak' wave formation in water of moderate depth. We show that the bottom stress could be modelled by the quadratic drag law with an amplitude/bottom roughness-dependent drag coefficient. The asymptotic analysis yields Davey-Stewartson type equations with an added nonlinear complex friction term in the envelope equation. The friction leads to a decay of the spatially uniform wave amplitude and affects the modulational (Benjamin-Feir) instability. The instability develops only if the amplitude of the background wave exceeds a certain threshold. The focus of the study is on the effect of friction on the formation of nonlinear patterns. Numerical experiments show that even when the friction is small compared to the nonlinear term, it hampers formation of the Akhmediev/Ma type breathers (believed to be weakly nonlinear 'prototypes' of freak waves) at the nonlinear stage of instability.

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MS7

Soliton
Solutions of 2-dimensional Periodic Volterra System

The 2–dimensional Volterra system is a discretized generalization of the Kadomtsev-Petiashvili equation. Rather interesting soliton solutions are derived and discussed.

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MS7

Searching for Integrable PDEs: Methods and Results

The integrability of a system of PDEs in the plane which is based on a nonlinear Fourier-type analysis follows from the existence of a matrix-valued function which depends on the plane coordinates and one spectral complex variable. A general method to generate such auxiliary function is introduced and examples of new integrable PDEs are given and investigated.

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MS7

Algebraic Reductions of Integrable PDEs: An Overview

All properties of integrable equations are encoded in their Lax representations: in this setting, the nonlinear equation is equivalent to the compatibility condition of a pair of linear equations, called a Lax pair. Unfortunately, given an integrable nonlinear equation, there is no algorithmic way to find its Lax representation. A different way to look at this problem consists in starting from a quite general Lax representation which yields a rather big (but integrable) system of equations. In general, such a system has too many degrees of freedom and is very complicated. However, it can contain smaller subsystems, relevant for applications: many well known integrable equations (such as the sine-Gordon equation) are indeed the result of reductions of more general integrable systems. This observation suggests the study and classification of possible Lax representations and their reductions. In this talk I will review the concept of algebraic reductions, discuss a few applications of this technique and the corresponding equations.

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MS7

Analytic Description of the Gradient Catastrophe of Two-dimensional Water Waves Near the Shore

We present the Inverse Spectral Transform for one - parameter families of vector fields, and we use it to construct the formal solution of the Cauchy problem for the dispersionless Kadomtsev - Petviashvili equation, a 2+1 dimensional PDE describing the evolution of two dimensional shallow water waves near the shore. We also show how a localized wave evolving according to such equation breaks at finite.

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MS8

Wellposedness of a Shallow Water Equation

This lecture deals with the wellposedness of the Cauchy problem for the Degasperis-Procesi equation that is a nonlinear, dispersive, of the third order. It describes the dynamics of shallow water waves and is one order more accurate of the KdV one. We study the entropy weak solutions, that are distributional solutions satisfying some additional entropy condition of Kruzkov type. Moreover, the unique entropy weak solution of the problem satisfies an Oleinik type estimate.

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MS8

Streamlines and Particle Trajectories of Steady Water Waves With and Without Vorticity

Travelling water waves can be described as an elliptic free-boundary problem. With vorticity this equation becomes nonlinear. We show some of the differences and similarities between the setting of irrotational and that of rotational flow. In particular we study the classical question of particle trajectories, and show that for both the linearized system, and for the full equations, the particle trajectories are in general nearly closed ovals with a slight forward drift. This is in contrast with the classical approximation showing closed ellipses.

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MS8

Existence and Stability of Shocks with Geometric Structure

We report on recent results on stability (and existence) of multi-dimensional gas-dynamical shocks with geometric structures. We present a framework which is general enough to study time dependent structures. As a simple example we present a spectral (hydrodynamical) stability analysis of standing shocks with cylindrical symmetry.

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MS8

Traveling Waves for the Whitham Equation

The Whitham equation is a model equation for small amplitude waves on the surface of a fluid. The equation is similar to the Korteweg-de Vries equation, but disposes of the assumption of small depth and large wavelength. Here, the focus is on traveling wave solutions of the Whitham equation. We indicate a proof of existence of small amplitude traveling waves, and present some numerical approximations of these traveling waves.

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MS9

Spurious Solitons and Structural Stability of Finite Difference Schemes for Nonlinear Wave Equations

The goal of this work is to determine classes of traveling solitary wave solutions for a differential approximation of a finite difference scheme by means of a hyperbolic ansatz. It is shown that spurious solitary waves can occur in finite-difference solutions of nonlinear wave equation. The occurance of such a spurious solitary wave, which exhibits a very long life time, results in a non-vanishing numerical error for arbitrary time in unbounded numerical domain.

Such a behavior is referred here to has a structural instability of the scheme, since the space of solutions spanned by the numerical scheme encompasses types of solutions (solitary waves in the present case) that are not solution of the original continuous equations.

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MS9
Traveling Wave Phenomena in a Animal Dispersal Model

In this paper, we study a density-dependent diffusion model with nonlinear rate of growth. Applying the center manifold theory, we show that under certain conditions, the nontrivial bounded traveling wave solution for the system is monotone or oscillatory. We then present a class of traveling wave solutions to the nonlinear reaction-diffusion system by a direct method

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MS9
Solitary Elastic Waves in Periodic Media

We consider nonlinear elastic waves in periodic one- and two-dimensional media. The periodicity of the medium gives rise to an effective dispersion, which, combined with the nonlinear, can lead to solitary wave behavior. The case of a one-dimensional, piecewise constant, two-material medium was considered previously [LeVeque 2002, LeVeque & Yong 2003]. We consider more general media and use both direct simulation and homogenization theory to determine what parameters lead to solitary wave generation. We also present analytic results on the stability and other properties of these waves.

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MS9
A Two-Pattern Mode Ecological System

In this paper, we study the dynamical behavior of a species which inhabits two independent habitat patches. Due to the long range foraging be- havior, frequent transfers happen between two patches with an exponentially decaying nonlinear transfer rate. Periodic oscillation is observed as a Hopf bifurcation occurs at some critical values of the delay. By applying the cen- ter manifold theorem, the Poincare normal form and the approximate periodic solution near the critical delay values are obtained. The complete synchroniza- tion of variations of the population size of species in two patches is analyzed and numerical simulations under various parametric conditions are illustrated.

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MS10
Radial Snaking

The existence and bifurcations of localized structures in 1D systems can be explained to a great extent by the homoclinic snaking of the spatial dynamics. In 2D, however, the scenario is more complicated. An intermediate situation is the formation of structures with cylindrical symmetry, described by a radial equation. Here I will discuss the case of localized structures formed from the pinning of circular domain walls. The key role of the curvature will be analyzed.

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MS10
Localized Structures as Spatial Hosts for Unstable Modes

We study spatially extended systems undergoing dual instabilities to temporal oscillations and periodic spatial patterns. We focus on localized structures in mono-stability regimes where one mode nonlinearly damps the other. Using normal-form equations, we find new instabilities of pure-mode spatial structures giving rise to mixed-mode structures and phenomena. These include breathing fronts and vortices in otherwise stationary patterns, pulses propagating along the core lines of breathing fronts, and controllable slowing down of propagating fronts.

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MS10
Hopf Bifurcation from Localized Structures

I will review old and new results on Hopf bifurcation from localized structures with an emphasis on the role of essential spectra. In particular, I will discuss instability caused by point spectrum in the presence of critical continuous spectrum and instability caused by continuous spectrum in the presence of critical point spectrum. Examples include dissipative fronts and pulses, viscous shock waves, and two-dimensional structures such as spiral waves.

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MS10
Localized Bare Soil Spots and Fairy Circles in Arid

Landscapes

It is common in arid or semi-arid regions to encounter landscapes where the vegetation cover is non-uniform and exhibits large scale structures, called 'vegetation patterns'. We present a model which accounts for clustering behavior, formation of localized bare soil spots (sometimes also called fairy circles) and attractive or repulsive interactions in arid environments Comparison with field measurement are presented.

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MS11

Pulse Fluctuations in Statistical Light-mode Dynamics

The noise in a mode locked laser cavity generates not only random fluctuations in the macroscopic parameters of the pulse, like its power and timing, but also random phase fluctuations of the mode amplitudes, that can even lead to the 'melting' of the pulse as shown in statistical light-mode dynamics - the nonlinear dynamics of laser modes under the influence of noise. I will explain how the pulse parameters and their fluctuations are affected by the cavity noise and mode entropy, using statistical light mode dynamics for a quantitative description.

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MS11

Nonlinear Mode-coupling for Mode-locking

We observe nonlinear pulse reshaping of femtosecond optical pulses in a waveguide array due to coupling between waveguides. The output temporal width shows power-dependent pulse shortening, in agreement with theory. This can be attributed to the peak of the pulse self-focusing into the central waveguide, while the lower power wings are effectively removed via evanescent wave coupling to outer waveguides. Understanding this phenomenon will be critical for development of a waveguide array based mode-locked laser.

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MS11

High Repetition Rate Octave Spanning Lasers and Frequency Combs

Over the last years we have developed octave spanning Ti:sapphire lasers at various repetition rates and most recently scaling to 1 and 2 GHz has been achieved. The most recent versions generate output spectra covering well over one octave even on a linear scale, such that direct 1f-to-2f interferometry of the laser output generates carrier-envelope beat notes ¿50dB. These lasers have been used for the construction of optical clocks and calibration combs for applications in astro-physics. In this presentation, the dynamics of octave spanning Ti:sapphire lasers will be reviewed as well as the technical challenges with respect to scaling to high repletion rates. We present a detailed study of the intensity-related carrier-envelop (CE)-phase dynamics in octave-spanning frequency combs (OSFCs) and a complete noise analysis of the CE-phase-lock loop (PLL) dynamics which reveals the current limitations to achieve minimum CE phase. We have measured shift of the CE-frequency fCE and the relative change in intracavity power versus pump power for a 200 MHz OSFC. A simple linear behavior is found, provided the correct pump power level is used to prevent the appearance of pulse instabilities such as a continuous-wave (cw) breakthrough. In the range where single pulse operation occurs, these data are in excellent agreement with theoretical predictions by Haus and Ippen based on soliton-like pulse propagation in Kerr media. It turns out that the intensity dependence of the CE-phase dynamics in OSFCs is significantly simpler than in systems which employ external spectral broadening to achieve the required octave, where the effect of intensity-dependent spectral shifts of the comb was found to be of importance. In OSFCs, in contrast, the center frequency of the pulse has no observable variation with pump power, because the pulse spectrum completely fills up the available bandwidth and is in fact limited by the bandwidth of the output couplers available. Different strategies for further reduction of the CE phase noise will be discussed.

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MS11

Cubic-Quintic Ginzburg Landau Pulses in Normal

and Anomalous Dispersion Fiber Lasers

Modelocked fiber lasers in which pulse-shaping is based on filtering of a frequency-chirped pulse are analyzed with the cubic-quintic Ginzburg-Landau equation. A range of experimental pulse shapes are predicted remarkably well by an exact analytical solution, and constitute dissipative temporal solitons. Normal dispersion fiber lasers allow systematic exploration of this class of solitons. Anomalous dispersion fiber lasers are also found to exhibit Ginzburg-Landau solitons with large pulse energy, chirp and duration.

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MS12

Spatially Correlated Noise in the Baer and Rinzel Model

The Baer and Rinzel model of spiny dendritic tissue, couples a passive cable to a continuous distribution of active spines. Here we introduce some multiplicative noise, white in time and correlated in space, to the spine dynamics which are modelled by the Hodgkin Huxley equations. Using a small noise expansion to approximate the full stochastic system we explore the parameter space, using the AUTO package, to find the existence and speed of different travelling wave solutions. These results are compared to direct simulation of the full stochastic system and to the results previously found for the deterministic case (Lord and Coombes 2001).

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MS12

Effects of Spatially Correlated Additive Noise on Neural Populations

Recent theoretical studies have shown that neural field models subjected to additive noise are well-suited models to explain experimentally observed brain activity. The presented work analyzes two stochastic spatially extended models, which describe neural populations driven by additive spatially correlated noise. The first model aims to reproduce the power spectrum of neural activity in a delayed feedback system found experimentally in electric fish. We show briefly the derivation of the model equation, discuss the power spectrum dependent on the spatial correlation length and compare the results to the experimental findings. In contrast to this linear analysis, a second neural population model is studied by a nonlinear analysis taking into account additive noise. We show analytically by a stochastic center manifold analysis that additive global noise, i.e. noise constant in space and uncorrelated in time, shifts the stability threshold towards larger values.

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MS12

Stochastic Soliton Dynamics in Random Medium

We develop a stochastic dynamical description for an optical soliton pulse propagating according to Maxwell-Bloch dynamics through an optically active medium with statistical spatial fluctuations in the population densities of the excitation states of its atoms. By combining inverse scattering theory with results from the theory of stochastic processes, we characterize the soliton behavior rather precisely. We place particular attention to how the polarization of the soliton switches stochastically between opposite circular polarization states.

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MS12

Wave/Current Interactions and Wave Breaking Dissipation

If wave breaking modifies the Lagrangian fluid paths by inducing an uncertainty in the orbit itself and this uncertainty on wave motion time scales is observable as additive noise, it is shown that within the context of a wave/current interaction model for basin and shelf scale motions it persists on long time scales. The model of McWilliams/Restrepo/Lane (04) provides the general framework for the dynamics of the wave-current interactions. In addition to the deterministic part, the vortex force, which couples the total flow vorticity to the residual flow due to the waves, will have a part which is associated with the dissipative mechanism. At the same time the wave field will experience dissipation, and tracer advection is affected by the appearance of a dissipative term in the Stokes drift velocity. Consistency leads to other dynamic consequences: the boundary conditions are modified to take into account the diffussive process and proper mass/momentum balances at the surface of the ocean.

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MS13

Damping of Internal Waves for Stratified Fluid and the Associated Nonlinear Eigenvalue Problem

We will describe a new method to study a classical problem: How long does it take the waves in a container of fluid to settle? To date there is no complete mathematical analysis; the air/liquid/wall contact line and surface tension complicate things. But for supercritical fluids at high pressure (important in several industrial processes, such as decaffeination of coffee) modeled by the incompressible Navier-Stokes equations, the sharp distinction between liquid and vapor disappears. Viscosity can be expected to damp internal waves with a characteristic exponential relaxation time associated with the slowest decaying mode of the system. This work proves that, surprisingly, there is no slowest decaying mode in such stratified fluids.

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MS13

Stability of One-dimensional Water Waves

We extend Viswanath's numerical Lindstedt-Poincare method to apply to nonlocal equations. This allows us to construct solutions of the one-dimensional Euler equations using the formulation of Ablowitz, Fokas and Musslimani. The spectral stability of these solutions is examined using Hill's method.

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MS13

Detecting Integrability in Water-Wave Equations

The question of the integrability or otherwise of partial differential equations arising in applications, for example in decribing water waves, is one with a relatively long history. Even in the case of non-integrable equations, techniques which arose originally within the context of integrable systems are often used. However, such techniques are not always so readily applicable. Here we consider the difficulties which arise in determining the integrability of certain classes of partial differential equation.

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MS13

Explosive Instability Due to Either 3-wave or 4-wave Mixing

It is known that an explosive instability can occur when nonlinear waves propagate in certain media that admit 3-wave mixing without dissipation. Recent work by Safdi and Segur (2007) has shown that explosive instabilities can occur even in media that admit no 3-wave mixing. Instead, the instability is caused by 4-wave mixing, also without damping: four resonantly interacting wave trains gain energy from a background, and all blow up in a finite time. Unlike singularities associated with self-focussing or wave collapse, these singularities can occur with no spatial structure - the waves blow up everywhere in space simultaneously. This talk reviews both of these cases, and shows that (a standard kind of) damping cannot stop the blow-up, with either 3-wave or 4-wave mixing.

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MS14

Discrete Snaking: Cavity Solitons in Discrete Saturable Media

Discrete localised structures are found in optical cavities with focusing saturable nonlinearity. Families of both bright and grey solitons exhibit multistability as they develop internal shelves in the pinning region around a Maxwell point. Both saturability and discreteness are required for these solitons to be observable, but they can occur for either zero or finite losses. We also discuss the complex morphology of these snakes as parameters vary, including cases of both focusing and defocusing nonlinearity, both with and without dissipation.

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MS14

Stability of Breathers in the Discrete Nls

We present analytical results on the linear stability of classes of breather solutions of the discrete NLS equation near the anticontinuous limit. We consider the case of both real and vortex breathers. The analysis is based on explicit perturbative constructions of the breather profiles and spectra.

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MS14

The Fermi-Pasta-Ulam Problem and the Korteweg-de Vries Equation: Recent Advances

The privileged role of the Korteweg-deVries (KdV) equation in the Fermi-Pasta-Ulam problem is discussed. In particular it is shown that the resonant Hamiltonian normal form equations of the FPU dynamics with N degrees of freedom coincide with the Fourier-Galerkin truncation to the first N modes of one suitable KdV equation. Some scaling laws numerically measured in the FPU dynamics are also discussed in the light of the KdV-normal form equation.

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MS15

Stability of Lumps and Wave Collapse

This study is concerned with the class of gravity-capillary lumps recently found on water of finite or infinite depth for Bond number, B ¡ 1/3. In the near-linear limit, these lumps resemble locally confined wavepackets and can be approximated in terms of a particular steady solution (ground state) of an elliptic system of the Benney-Roskes-Davey-Stewartson (BRDS) type. According to the BRDS equations, however, initial conditions above a certain threshold develop a singularity in finite time owing to nonlinear focusing; the ground state, in fact, being on the borderline between existence and wave collapse suggests that the newly discovered lumps are unstable. Based on the fifth-order KP equation, a model for gravity-capillary waves when B is close to 1/3, it is pointed out that an exchange of stability occurs at a certain finite wave steepness, lumps being unstable (stable) below (above) this critical value. As a result, a small-amplitude lump, that is linearly unstable and would be prone to wave collapse according to the BRDS equations, depending on the perturbation, either decays into dispersive waves or evolves to an oscillatory state near a finite-amplitude stable lump. The effect of external forcing on the dynamics of lumps will also be discussed.

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MS15

Maslov Index and Applications to the Stability of Solitary Waves

The spectral stability of a soliton in one space dimension is often related to eigenvalues of a self-adjoint operator. To count these eigenvalues, various index definitions based on the Maslov index and the ordinary differential equation satisfied by the soliton are considered, including a new one based on a limit of periodic waves. Theory and numerics using exterior algebra are applied to solitons arising in the fifth order Korteweg-de Vries equation.

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MS15

Two-layer Flows with Free Surface

We derive a dispersive model for description of long large amplitude waves propagating in a two-layer system with free surface. We study travelling wave solutions to this system. Their study reduces to the analysis of a Hamiltonian system with two degrees of freedom. We have shown the existence of homoclinic trajectories embedded into the continuous spectrum. They correspond to true solitary waves having the same velocities at infinity in each layer. The travelling-wave solutions depend on three parameters: the density ratio, the depth ratio and the Froude number based on the bottom layer. Two wave regimes, characterized by the elevation or depression of the interface between the layers are presented. A critical depth ratio separates these two regimes and it will be shown how it relates to a change of the structure of the potential for the Hamiltonian system. The analysis of the number and nature of critical points turned out to be decisive in this work. It was found that the number of critical points can be four or two, depending on the value of the Froude number (for fixed density and depth ratios). For sets of parameters corresponding to oceanic conditions we have perceived the existence of true solitary waves and their broadening whenever the speed wave increases towards a limit value. Finally, other sets of parameters are considered for which multi-humped solitons exist, highlighting the richness and complexity of the system considered.

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MS15

Stability of Nonuniform Shear-Stratified Shallow Water Flows

We discuss stability properties of nonuniform flows within the hydrostatic shear-stratified shallow water equations. Both in the “layered” case and in the continuous stratification limit are studied. In the two-layer case, we find necessary and sufficient conditions for a nonlinear stability theorem. In the three-layer case we show that no such simple theorem is possible. In fact we show that a necessary condition for fluid stability within the context of hyperbolic systems is violated in certain cases and we can construct nonuniform initial data that are initially stable but that develop instabilities as it evolves. In the continuous limit we can find results similar to those of Howard albeit for nonuniform flows.

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MS16

Three Waves Resonant Interaction Solitons: Novel Features and Applications in Nonlinear Optics

The nonlinear three-wave resonant interaction (TWRI) is a universal model, which describes a variety of physical systems (plasma physics, nonlinear optics, etc). TWRI system is integrable and admits soliton solutions both of bright and dark type. We recently found novel solitons of simulton (velocity loked), boomeron (accelerating) and trappon (periodic) type. We shall discuss the properties of these solutions with particular attention to their interactions, spectral properties and applications in the field of nonlinear optics.

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MS16

Novel Shape Changing Soliton Collisions in Mixed Coupled Nonlinear Schroedinger Equations

Abstract not available at time of publication.

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MS16

Is Free Surface Deep Water Integrable System?

Equations or Free Surface Hydrodynamics in 1+1 geometry on deep water demonstrate several idiosyncrasy treits which make reasonable the hyposis that these equations are completely intergrable.These unusial features are: 1. The coupling coefficient for four-wave intercation on the resonant surface is identically zero. 2.The equations have extra constants of motions.Their number depends on the initial data. 3. The equations have long-living breather-type solutins of high amplitude. However the Lax pair or its analog for dispersionles systems are not found so far.

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MS16

Inelastic Soliton Interactions in Solutions of the Perturbed KdV Equation

In the multiple-soliton case, the solution of the perturbed KdV equation is decomposed into a sum of elastic and inelastic components. The elastic component is the same perturbation series as in the single-soliton case, and preserves the elastic nature of soliton collisions. Typical inelastic contributions are radiative tails and soliton-anti-soliton waves. Specific initial data generate soliton-anti-soliton creation or annihilation, soliton decay or amalgamation and inelastic soliton deflection.

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MS17

Step-flow Growth of a Crystal Surface by Levy Flights

Step-flow growth of a crystal surface is considered in the case when the adatom diffusion on the terraces is governed by Levy flights. A superdiffusive analog of the Burton-Cabrera-Frank (BCF) theory is developed, and the step-flow velocity of a traveling wave of steps on the crystal surface is found as a function of the terrace width and the Levy exponent. It is shown that the Levy-flights-controlled step-flow velocity is lower than that in the case of normal diffusion.

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MS17

Fractional Dynamics in Biology and Ecology

There has been growing evidence that in many complex systems the simple Brownian diffusion picture breaks down. Instead, one observes anomalous diffusion, which can be sub or super-diffusive. A framework to describe such anomalies will be introduced with recent examples from biological and ecological systems. In particular we will relate the anomalous behaviors to search patterns and to motion patterns that are modeled by Levy walks.

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MS17

Fractional Dynamics in Pattern-forming Systems

Modelling of anomalous diffusive processes involves fractional derivatives or similar memory operators. Though linear stability of reaction systems with anomalous diffusion received significant attention in the past years, scarcely few works address the non-linear evolution. The talk is dedicated to fractional analogues of amplitude (Ginzburg-Landau) and phase diffusion (Kuramoto-Sivashinsky) equations. General properties, analytical and numerical solutions, generalising such phenomena as phase and amplitude turbulence, defect chaos etc. are treated.

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MS17

Fractional Equations for Simple Reaction Kinetics

We discuss a general approach to mesoscopic description of reactions under subdiffusion as modelled within the picture of continuous time random walks, and show that the behavior of such reactions may be vastly different from the one in the diffusive case. Especially nontrivial situation is encountered in description of reversible reactions leading to propagating fronts, where the pushed or pulled dynamics of the front depends crucially on the assumptions on the reversible stage.

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MS18

Nonlinear Stability of Localized Two-Dimensional Rotating Waves

First we briefly review stability problems for nonlinear waves and their relation to the theoretical and numerical analysis of various types of spectra obtained from linearization. For the more specific case of localized two-dimensional and rigidly rotating patterns we present a result on nonlinear asymptotic stability in a suitable Sobolev space. The result applies to spinning solitons in the Quintic-Cubic Ginzburg Landau equation. This is joint work with Jens Lorenz (Albuquerque) and Vera Thuemmler (Bielefeld).

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MS18

Stability Computations for Two-dimensional Fronts Using the Evans Function

We study the stability of a travelling wrinkled front for cubic autocatalysis in two dimensions. The problem is reduced to a one-dimensional problem by Fourier decomposition. We then determine the stability by computing the Evans function. The size of the resulting system makes the common approach based on exterior product infeasible, but methods based on the Riccati or Drury-Oja equations do work. This seems to be the first Evans function computation for genuinely multi-dimensional fronts.

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MS18

Stability of Localized States Arising Through Snaking

This talk is concerned with the PDE stability of stationary localized 1D roll solutions of the Swift-Hohenberg equation. These localized structures are parametrized by the length L of their roll plateau, and their spectra contains approximately L eigenvalues near the origin. As L increases, the localized rolls undergo many saddle-node bifurcations. I will discuss how the overall spectra vary as functions of L and how they can be computed numerically.

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MS18

Freezing Stable Multipulses and Multifronts

In this talk we consider nonlinear parabolic systems in one space dimension that have multifront or multipulse solutions. We present a numerical method for decomposing solutions into a superposition of a finite number of fronts and pulses that travel with different velocities. Our approach extends the method of freezing single pulses to multifronts und multipulses. We demonstrate the method on two mathematical models that have stable multipulses and multifronts: the Nagumo equation and the FitzHugh-Nagumo equation.

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MS19

Spatially Localized Steady States in Binary Fluid Mixtures Heated from Below

Numerical simulations of convection in binary mixtures have shown the existence of confined states that consist of regions of developed steady convection surrounded by quiescent fluid. These localized states or "convectons" are observed to be stable, and in an infinite domain can contain an arbitrary number of convection rolls. We show that these states originate in an Eckhaus bifurcation from the uniform steady state of convection leading to two branches of even and odd solutions that snake back and forth, losing a pair of cells at each turn. For periodic domains the region of existence of the convectons (the width of the snake) is different for odd and even branches. In order to understand this behavior we will also study the snaking of convecton branches in closed containers.

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MS19

Spatially Localized States in Marangoni and

Double-diffusive Convection

Numerical continuation is used to compute a high multiplicity of stable spatially localized steady states in (i) natural doubly diffusive convection in a vertical slot driven by opposed horizontal temperature and concentration gradients (Ghorayeb & Mojtabi, *Phys. Fluids* 9, 2339, 1997), and (ii) Marangoni convection in a thin horizontal layer of a two-component fluid heated from above (Bergeon & Knobloch, *Phys. Fluids* 16, 360, 2004). Both systems exhibit bistability between the conduction state and a spatially periodic convecting state, and both are spatially reversible. The computations employ periodic boundary conditions with large spatial period and demonstrate the presence of homoclinic snaking (Burke & Knobloch, *Phys. Rev. E*, 73, 056211, 2006) in both systems.

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MS19

Homoclinic Snaking and the Eckhaus Instability

Homoclinic snaking is a term used to describe the back and forth oscillation of a branch of time-independent spatially localized states in a bistable, spatially reversible system as the localized structure grows in length by repeatedly adding rolls on either side. In systems that are unbounded in one spatial direction homoclinic snaking continues indefinitely as the localized structure grows to resemble a spatially periodic state of infinite extent. In finite domains or in periodic domains with finite spatial period the process must terminate. In this talk I describe the factors that determine the location of the termination points in the Swift-Hohenberg equation, and show that they are related to the Eckhaus instability of the spatially periodic state.

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MS19

Collision Dynamics of Localized Waves in a Model Equation of Binary Fluid Convection

We study the dynamics of spatially localized convection cells in binary fluid mixture. Experiments by Kolodner show various dynamical interactions between the localized cells (pulses) including bound state formation and destruction of pulse after the collision. Numerical analysis revealed that an amplitude equation proposed by Riecke reproduces these results. We will show the results of the analysis focusing on the idea of Scattor, the saddle solutions embedded in the collision process.

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MS20

The Dispersion-managed Ginzburg-Landau Equation and its Application to Femtosecond Lasers

We introduce the dispersion-managed Ginzburg-Landau equation (DMGLE) as an average model that describes the long-term dynamics of systems characterized by rapid variations of dispersion, nonlinearity and gain dynamics in a general setting. We then show how in particular the DMGLE arises for Ti:sapphire femtosecond lasers, we study the properties of the equation, and we characterize its solutions.

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MS20

The Splitting of Multisoliton Bound States of the Nonlinear Schrdinger Equation Induced by Linear Loss

We address the break-up (splitting) of multisoliton solutions of the Nonlinear Schrdinger Equation (NLSE), occurring due to the presence of linear loss. We demonstrate that in the case of strong non-adiabatic loss the evolution of the Zakharov-Shabat eigenvalues can be quite nontrivial displaying the eigenvalue coalescence and subsequent bifurcation leading to the splitting. We also demonstrate that the multisoliton splitting can take place even in the case of small linear loss.

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MS20

Anomalous Behaviour in Amplitude and Phase Jitter of Nonlinear Schrdinger Solitons

Importance sampling is a very effective tool in improving the efficiency of bit-error ratio calculations when a reduced dynamic model is available. When this model is imperfect, results from the biased Monte Carlo simulations can be used to improve the accuracy of the model and therefore the efficiency of the sampling technique. We demonstrate this procedure using examples where numerically calculated bit-error ratios deviate from those obtained using perturbation theory.

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MS20

Rare Events and pdf Scaling for Nonlinear Lightwave Systems

In recent years there has been much interest in predicting errors in nonlinear optical systems such as optical fiber communication systems and femtosecond lasers. Using semi-analytic and numerical methods, one can directly reconstruct probability distribution functions (pdfs) of signal parameters whose large deviations (rare events) are responsible for errors. For some applications of interest – specifically lasers – typical length scales exclude the possibility of applying these methods to predict the occurrence of rare events. To overcome this problem we study methods of pdf scaling. We validate this approach by comparing scaled distributions to directly simulated distributions in the context of nonlinear communication systems.

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MS21

The Importance of Space and Time Scales for Auxin Patterning in Root Development

Analysing Arabadopsis root through a multi-level modelling approach, in which molecular and cellular properties interplay, reveals a dynamical picture of pattern formation and morphogenesis. This talk will show the different timescales at which patterns are formed can be linked to the specific topolgoy of the localisation of proteins called PINS.

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MS21

Rops, Mutants, and Turing Patterns in Plant Root Hair Cells

The plant root hair system is a good study system for patterning at the cell level because of the number of genetic mutants for which characteristic phenotypes are known. In the wildtype, initiation of root hair growth starts with accumulation of a patch of ROPs on the cell membrane a short distance from the apical cell end. We make a reaction-diffusion model of the interaction of auxin with ROP activation at the cell level, and show how it can exhibit the wildtype pattern. We extend this to examine how the model can also account for several of the mutant phenotypes, including shifted patchs, double patches, and patches at the wrong end of the cell. Our model allows us to make a number of conjectures about the biology of root hair initiation.

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MS21

Modelling the Mutual Support of Differential Cell Fates in the Arabidopsis Root Epidermis

Patterning of the Arabidopsis root epidermis depends on a genetic regulatory network operating both within and between cells. Modelling genetic data has allowed us to explore both the sufficiency of known network interactions and the extent to which additional assumptions can account for wild type and mutant data. Our model has shown an existing hypothesis concerning the autoregulation of WEREWOLF does not account fully for the biological data. We have thus proposed an alternative mechanism. Modelling has been used to direct wet experiments that have verified the non existence of WEREWOLF auto-regulation and mirrored predictions made by our new mechanism.

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MS22

Linear Stability of Cnoidal Waves of the KdV Equation

Going back to considerations of Benjamin (1974), there has been significant interest in the question of stability for the stationary periodic solutions of the Korteweg-deVries equation, the so-called cnoidal waves. In this paper, we exploit the squared-eigenfunction connection between the linear stability problem and the Lax pair for the Korteweg-deVries equation to completely determine the spectrum of the linear stability problem for eigenfunctions that are bounded on the real line. We find that this spectrum is confined to the imaginary axis, leading to the conclusion of spectral stability. An additional completeness argument allows for a statement of linear stability.

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MS22

Numerical Modeling of Shallow Water Waves with Riemann Theta Functions: The Discovery of a New Type of Rogue Wave

The goal, scope and focus of this research program is to aim for improvement in wind-generated ocean surface wave models in the coastal zone. To this end we have addressed the problem starting with soliton theory, in particular for periodic/quasi-periodic boundary conditions. We begin with the KP equation and develop a "hyper-fast" algorithm using Riemann theta functions. To this end we show how theta functions, normally thought to execute in exponential time, can instead be computed in polynomial time. We give a fast theta function algorithm and show several examples including those with Riemann matrices of 30x30, 50x50 and 100x100. We have been able to work in spatial domains up to several kilometers on a side and typically use a 1000 x 1000 (x, y) grid for simulations with about 1000 time points. Both theoretical and numerical evidence

are given for the existence of a new type of rogue wave in shallow water. The new approach compares well to conventional models using the FFT; we find a speed up of about 1000 in computer time using the "fast theta function transform."

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MS22

Gravity Induced Dispersion for Nearly Flat Vortex Sheets

Using techniques from the theory of oscillatory integrals, we prove rigorous estimates which show that the linearization of the vortex sheet equations of motion about a quiescent state disperse under certain circumstances. Such dispersion is only possible only through the joint effects of surface tension (which damps high frequency modes) and gravitation (which damps low frequency modes).

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MS22

Modulational Instability, Freak Waves and Extra Constants of the Motion

Abstract not available at time of publication.

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MS23

Tunable Highly Nonlinear Dynamics of Granular Systems: An Experimental Approach

The observation of highly nonlinear solitary waves propagating in a one- and two- dimensional granular systems will be presented. The tunability of such pulses as well as the effects of interfaces, periodic heterogeneities and randomizations will be described. This work has lead to the observation of novel dynamic phenomena including anomalous reflections, pulse scrambling and energy trapping. The experimental results are supported by discrete numerical simulations and agree well with the highly nonlinear wave theory.

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MS23

Coherent Modes Versus Radiation in the Fermi-Pasta-Ulam

Abstract not available at time of publication.

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MS23

Nonlinear Waves in Dusty Plasma (Debye) Crystals: a New Test-Bed for Nonlinear Theories

Dust crystals are formed inside a plasma consisting of electrons, ions and massive charged mesoscopic-sized defects (dust 'grains'). Electrostatic interactions and an asymmetric anharmonic on-site potential due to the plasma sheath environment provide the ingredients to tailor-fit nonlinear wave theories, into a qualitative mélange of (hybrid) FPU and nonlinear Klein Gordon equations. The nonlinear aspects of dust motion in 1D and 2D (hexagonal) dust lattices are reviewed, distinguishing a longitudinal (acoustic) and a transverse (optic-like, backward wave) mode(s). Nonlinear excitations including kinks, density solitons and symmetric/asymmetric envelope wavepackets, are obtained via quasi-continuum soliton theories. Discrete breathers and vortex modes are found via discrete models (details in a separate presentation).

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MS23

Dark Solitons in Bose-Einstein Condensates

We study statics and dynamics of dark solitons in Bose-Einstein condensates trapped in harmonic and/or periodic (optical lattice) potentials. We find the spectrum and the characteristic eigenfrequencies of dark solitons, both in the purely one dimensional case and in the dimensionality crossover regime. In the case of the harmonic trap we find the oscillation frequency of the dark soliton and show that it coincides with the anomalous mode eigenfrequency. In the case of the periodic potential, we find that dark solitons are subject to a weak oscillatory instability. Finally, we show that dark soliton dynamics can be manipulated by appropriate time depended periodic potentials.

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MS24

Stability and Propagation of Pulses in Nonlinear Schrodinger Models

Nonlinear Schrodinger equations (NLS) with complex,

variable coefficient can model pulse propagation in inhomogeneous media with energy gain or attenuation. Special exact solutions are obtained by first isolating the chirp factor and a variant of the Hirota bilinear method. A competition between linear gain/loss versus their nonlinear counterparts is assessed. For coupled NLS systems, instability will depend on the number of components, and the relative magnitude of the cross and self phase modulation coefficients.

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MS24

Gap-solitons in Fuid Flows

We seek gap-solitons using an asymptotic development of a three-layered stratified shear flow, which leads to a system of coupled first-order envelope equations along with a set of mean-flow equations. It is shown that this system can support gap-soliton solutions. A special class of such solitons is then studied, for the case when the envelope and carrier speeds are identical leading to steady traveling solutions. Further manifestations of gap-solitons in geophysical flows are then studied, through the normal form approach that exploits dynamical systems methods, for a generic system of coupled Korteweg-de Vries equations.

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MS24

Propagation of an Envelope Solitary Wave Over Variable Depth

Envelope solitary waves can be described by the nonlinear Schrodinger (NLS) equation, for the focusing case. This is the case for deep water waves, when $kh > 1.363$. Here we consider the propagation of an envelope solitary wave from deep to shallow water. In the vicinity of the critical depth where $kh = 1.363$ it is necessary to extend the model to a higher order NLS equation with variable coefficients. We find that then the envelope solitary wave can exist for $kh > 1.1978$, thus penetrating further into the shallow water regime.

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MS24

Solitary Waves Interacting with Highly Disordered Microstructures

The interaction of solitary waves with highly disordered topographies is analyzed by first choosing a special system of (variable coefficient) Boussinesq equations. In the wave/topography regime considered the variable coefficient can be modeled as being random. Asymptotically this coefficient manifests itself as an apparent diffusion term, namely giving rise to an effective Burgers-KdV equation. Numerical experiments will be presented to illustrate some theoretical results. If time permits modeling issues will be briefly discussed, regarding variable coefficient Boussinesq systems.

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MS25

Conical Wave Pulses for Phase-matched Extreme-frequency Conversion

Conical Wave pulses, in particular Pulsed Bessel Beams and X Waves, may be used to greatly increase the efficiency of nonlinear frequency conversion processes such as Raman conversion, second and third harmonic generation or even higher order harmonic generation in the extreme UV region. We present our latest results in this area with particular emphasis on the various phase-matching schemes that may be employed using Conical Wave pulses.

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MS25

Nondiffracting Single Photons and Quantum Interference Experiments

Nondiffracting propagation of single photons generated by modified Young-type interferometers was studied with spatially resolved EMCCD technique. Two experiments were performed. Multiple needle-shaped propagation zones were generated by spatially filtering Bessel beams. Far-field distributions indicate that single photons pass the apertures with minimum diffraction in case of self-apodized truncation. Single photon detection after beam shaping with a reflective axicon yields an envelope Bessel distribution. The quantum mechanical aspect of the nonlocality is well confirmed.

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MS25

Thermalization of Incoherent Nonlinear Waves

The thermalization of a nonlinear wave is characterized by an irreversible evolution of the field towards a thermodynamic equilibrium state, in complete analogy with kinetic gas theory. We show that the thermalization pro-

cess may be responsible for a self-organization of the field, e.g., wave condensation or velocity-locking of incoherent wave-packets. Spectral incoherent solitons will also be introduced, i.e., solitons that do not exhibit a localization in the spatiotemporal domain but exclusively in the frequency domain.

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MS25

Linear and Nonlinear Localized Waves: State of the Art

Abstract not available at time of publication.

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MS26

Bayesian Parameter Estimation of Reduced Nonlinear Geophysical Systems

In atmosphere-ocean science, slowly evolving coherent large-scale structures like the so called North Atlantic Oscillation, and their statistical behavior, are often of the most interest, and yet the computational power of complex climate models is spent on resolving the smallest and fastest variables in the system. To provide computationally feasible alternatives for calculating the statistical behavior of the climatologically relevant slow variables the nonessential degrees of freedom can be represented stochastically. Recently a systematic stochastic mode reduction procedure was developed which predicts the functional form of nonlinear reduced stochastic models for complex geophysical systems. The predicted nonlinear functional form contains both additive and multiplicative noise terms. In my talk I will utilize this functional form and a Bayesian Markov Chain Monte Carlo (MCMC) procedure for the estimation of the parameters of the reduced model from geophysical data sets. This procedure is able to estimate the parameters for nonlinear terms as well as for both additive and multiplicative noises. The reduced models still have a relative large number of parameters; on the order of 1000 for a 10 dimensional state vector. An explict assumption of reduced order modeling is the stability of the reduced model. In this talk I will show how the stabillity property of the reduced model can be utilized to construct parameter constraints for the MCMC procedure. Such constraints improve the accuracy of the estimation procedure. Without such constraints the parameter estimation procedure might lead to unstable reduced models. Some simple examples will illustrate how unstable, and thus unphysical solutions, can produce bimodal posterior distributions.

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MS26

On Simultaneous Data–based Dimension Reduction and Hidden Phase Identification

In recent years there has been considerable increase of interest in the mathematical modeling and analysis of complex systems that undergo transitions between several phases or regimes. Such systems can be found, e.g., in weather forecast (transitions between weather conditions), climate research (ice and warm ages), computational drug design (conformational transitions) and in econometrics (e.g., transitions between market phases). In all cases the accumulation of sufficiently detailed time series has led to the formation of huge databases containing enormous but still undiscovered treasures of information. However, the extraction of essential dynamics and identification of the phases is usually hampered by the multidimensional nature of the signal, such that the information remains hidden in the time series. Standard filtering approaches (such as wavelet-based spectral methods) generally suffer from unfeasible numerical complexity in high-dimensions, while other standard methods (such as Kalman-filter, MVAR, ARCH/GARCH etc.) impose some strong assumptions regarding the type of the underlying dynamics. Several new mathematical methods for simultaneous data-based dimension reduction and identification of hidden phases in high-dimensional time series will be presented. The methods exploit the topological structure of the analysed data an do not impose severe assumptions on the underlying dynamics. Special emphasis will be placed on the mathematical assumptions posed in the construction of those methods, the issue of confidence interval estimation and the numerical costs for high-dimensional applications. The application of the presented methods will be first demonstrated on a toy example and the results will be compared with the ones obtained by standard approaches. The importance of accounting for the mathematical assumptions used in the analysis will be pointed up in this example. Finally, we present recent applications of these tools to data analysis and prediction based on meteorological data.

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MS26

Intrinsic Time Scales of Lévy–driven Jump–diffusions

Let Y be a one–dimensional dynamical system described by the differential equation $\dot{Y}_t = -U'(Y_t)$ with a unique stable point at the origin. We perturb the system by Lévy noise L, to obtain the stochastic differential equation $dX_t^\varepsilon = -U'(X_t^\varepsilon)dt + \varepsilon dL_t$, ε being a small parameter, and study the first exit times of X^ε from the interval $[-1, 1]$ in the limit $\varepsilon \to 0$. In particular, we consider perturbations by symmetric Lévy processes whose jump measure has power, sub– or super–exponential tails, and compare the results with the well–known Gaussian case.

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MS26

Stochastic Mode–Reduction in Large Deterministic Systems

A new stochastic mode-elimination procedure is introduced for a class of deterministic systems. Under assumptions of mixing and ergodicity, the procedure gives closed-form stochastic models for the slow variables in the limit of infinite separation of time-scales. We show that under these assumptions the ad-hoc modification of the nonlinear self-interactions of the fast degrees of freedom can be avoided. The procedure is applied to the truncated Burgers-Hopf (TBH) system as a test case where the separation of timescale is only approximate. It is shown that the stochastic models reproduce exactly the statistical behavior of the slow modes in TBH when the fast modes are artificially accelerated to enforce the separation of timescales. It is shown that this operation of acceleration only has a moderate impact on the bulk statistical properties of the slow modes in TBH. As a result, the stochastic models are sound for the original TBH system.

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MS27

Stability of Discrete Solitons in the DNLS Equation: Towards a Classification of Both Defocusing And Focusing Cases And Connections With Experiments

In this talk, we will give an overview of the existence and stability of discrete soliton solutions in both the focusing and defocusing Discrete Nonlinear Schrodinger (DNLS) equation. We will start from the 1d case, and gradually build towards higher-dimensional settings (2d and even 3d). Finally, we will attempt to connect the resulting bright, dark and gap discrete soliton solutions to recent experimental efforts in Bose-Einstein Condensates and, especially, in nonlinear optics.

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MS27

Asymptotic Stability of Ground States in NLS

We consider the nonlinear Schrödinger equation in three space dimensions with an attractive potential. The nonlinearity is including both sub-critical and supercritical (in L^2) nonlinearities. Our result shows that all solutions with small, localized in space initial data, converge to a nonlinear bound state. Therefore, the nonlinear bound states are asymptotically stable.

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MS27

On Asymptotic Stability in Energy Space of Ground States of NLS in 2D

We prove dispersive and smoothing estimates for dispersive solutions of the linearization at a ground state of a Nonlinear Schrödinger equation (NLS) in 2D. As an application we extend to dimension 2D a result on asymptotic stability of ground states of NLS proved in the literature for all dimensions different from 2. This is a joint work with S. Cuccagna.

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MS27

Energy Equipartition in the Nonlinear Schroedinger / Gross Pitaevskii Equation

We consider a general class of multi-moded Nonlinear Schroedinger / Gross Pitaevskii equations in the low energy regime. We prove the large time selection of the ground state and an asymptotic energy equi-partition law. This is joint work with Gang Zhou.

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MS28

Numerical Continuation of Fully Two-dimensional Localised Patterns

We present a general approach for the numerical continuation of coherent structures in PDEs by means of finite differences. The method is employed to continue stationary localised patterns of the planar cubic-quintic Swift-Hohenberg equation. Such patterns consist of a set of horizontal stripes connected to the rest state at infinity via a set of spots. The solutions are found to exhibit both snaking and non-snaking behaviour in different regions of the parameter space.

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MS28

Stability of Curved Interfaces in the Perturbed Two-dimensional Allen-Cahn System

We consider equilibrium solutions to a perturbed Allen-

Cahn model in bounded 2-dimensional domains that have the form of a curved interface. Using singular perturbation techniques, we fully characterize the stability of such an equilibrium in terms of a certain geometric eigenvalue problem, and give a simple geometric interpretation of our stability results. Full numerical computations of the associated two-dimensional eigenvalue problem are shown to be in excellent agreement with the analytical predictions.

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MS28

Localized Structures in the Liquid Crystal Light-valve Experiment

We present a review of experimental observations in the liquid crystal light-valve with optical feedback, showing different types of localized states, such as the circular and triangular localized structures and the localized peaks. We discuss the different features of these localized states and we present a method to control their dynamics through the application of suitable phase profiles. Finally, we discuss the theoretical background on the basis of a generic local model.

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MS28

Localized Patterns in Lattice Dynamical Systems

We consider a discretized diffusion equation with a bistable 'cubic-quintic' nonlinearity, on a square lattice of nearest-neighbour and next-nearest-neighbour coupled cells. Bifurcations to spatially periodic checkerboard and stripe patterns occur from the trivial state; these patterns saturate at finite amplitude even when the 'diffusive' coupling terms have negative coefficients. A variety of localized checkerboard and stripe patterns also arise. We compare the bifurcation structure with that obtained in the spatially continuous canonical case.

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MS29

A Waveplate Hinge Model for Polarization-mode Dispersion in Installed Fibers

We study an anisotropic hinge model of the PMD in fibers,in which, the action of the polarization hinges is a random, time-dependent rotation about a fixed axis. The outage probability of an individual frequency band is obtained using a combination of importance sampling and the cross-entropy method, and averaging over frequency bands then yields the non-compliant capacity ratio. Significant differences between the outage statistics predicted by isotropic and anisotropic hinge models are demonstrated.

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MS29

Stochastic Modeling of the Polarization-mode Dispersion Dynamics

We report on recent advances in the study of the temporal dynamics of PMD. We will introduce stochastic models of the temporal evolution of PMD, highlighting their ability to reproduce key-features of the temporal PMD statistics experimentally observed in installed fiber systems.

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MS29

Modeling of Randomly Birefringent Spun Fibers

Spun fibers are the most viable solution to fiber optic links with low polarization mode dispersion. The presentation reviews the modeling of such fibers, highlighting the critical role played by the birefringence autocorrelation.

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MS29

Polarized Nonlinear Amplifiers in Random Birefringent

Polarized gain in randomly birefringent and spun fibers is theoretically and numerically studied for Raman, Brillouin and parametric amplification. Unidirectionally spun fibers show the potential of providing high gain with reduced uncertainty.

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MS30

Fundamental Models of 1D Cardiac Tissue

We show that an excitatory media with global coupling is the most basic model to characterize the electro-mechanic heart dynamics. While the core of most electrical model in heart dynamics is an excitatory system which can be, in one of its most basic forms, be described by the FN equation, we demonstrate that the most basic simple mechanical coupling can be reduced to a two variable excitatory system with global coupling. We show that our model is identical to the Nash-Panfilov (NP) model in the linearly elastic regime and that it also reproduces all its behavior such oscillatory regimes, multiple stable focal points and the instability of spiral waves in front of increasing mechanical coupling. The model allows to study analytically the reason behind such interesting phenomena. We explicitly explain the new oscillatory regime that may arise in the NP model in terms of the system nullclines. Furthermore, the numerical simplicity of the model allows to make a thorough study of the phase space. In particular, we focus our attention in the dynamics of 1D systems where our model is directly relevant to experiments to obtain reasonable assessment of the effect that electro-mechanical feedbacks may have depending on its strength.

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MS30

The Mechanics of Hair Formation in Root Hair Cells

We present a novel methodology based on image processing techniques, mini- mum energy surfaces and the calculus of variations which allows us to infer the mechanical properties of growing Arabidopsis thaliana root hairs from time- lapse image data. Computer simulation of root hair emergence, modeled as a large set of interconnecting springs, allows for different growth models to be tested and validated against experimental data. With this approach we demonstrate that root hair initiation is consistent with purely elastic growth. Independent data from tracking fluorescent beads on growing cells show that simulation and experiment are in excellent agreement.

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MS30

Modelling Polarity and Bistability within Cells

This talk will discuss the possibility of generating polarity and bistability within plant cells as a consequence of tissue-level gradients, such as auxin, through internal small-G protein interactions. The models generated lend themsleves to phase-space analysis, and can be contrasted with the kind of patterns one sees in turing instabilities.

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MS30

Turing Patterns Inside Cells

Concentration gradients inside cells are involved in key processes such as cell division and morphogenesis. Here we show that a model of the enzymatic step catalized by phosphofructokinase (PFK), a step which is responsible for the appearance of homogeneous oscillations in the glycolytic pathway, displays Turing patterns with an intrinsic length-scale that is smaller than a typical cell size. All the parameter values are fully consistent with classic experiments on glycolytic oscillations and equal diffusion coefficients are assumed for ATP and ADP. We identify the enzyme concentration and the glycolytic flux as the possible regulators of the pattern. To the best of our knowledge, this is the first closed example of Turing pattern formation in a model of a vital step of the cell metabolism, with a built-in mechanism for changing the diffusion length of the reactants, and with parameter values that are compatible with experiments. Turing patterns inside cells could provide a check-point that combines mechanical and biochemical information to trigger events during the cell division process.

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MS31

On the Convergence of Hills Equation

Hill's method is used to numerically approximate spectra of linear operators associated with, for instance, forward scattering problems and stability problems for nonlinear waves. In this talk, I will discuss results on the convergence of Hill's method, the rate of convergence, and the convergence of the associated eigenfunctions.

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MS31

Non-symmetric Periodic Three-dimensional Gravity Water Waves

We consider travelling water waves in a potential flow on an infinitely deep fluid layer, which form a bi- periodic horizontal pattern on the free surface, in absence of surface tension. The pattern is not of diamond type, the two basic wave vectors K1 and K2 having different lengths. The waves may be considered as the nonlinear super- position of two plane waves, with corresponding wave numbers K1 and K2, and amplitudes "1 and "2, provided that at the bifurcation, K1,K2 and the bifurca- tion parameters (built with a wave length, the acceleration of gravity and the velocity of the waves) and the direction of propagation u0, satisfy the dispersion relation. We first show how to build the asymptotic expansion of bifurcating 3-dimensional waves defined up to a horizontal shift, as a power series of the amplitudes "1, "2, the direction of propagation being close to u0. All coefficients may be computed explicitely in terms of the two angles made by K1 and K2 with u0. Due to the occurence of small divisors, the main difficulty for prov- ing the existence of solutions, possessing the above asymptotic expansions, is the inversion of the linearized operator at a non trivial point, for applying the Nash Moser theorem. This operator is the sum of a second order differentiation along a certain vector field (having a non zero rotation number), and an integro- differential operator of first order, both depending periodically of coordinates. The idea of the method follows [G.Iooss, P.Plotnikov. Three-dimensional doubly-periodic travelling water waves. Memoirs of AMS (to appear) (119p.)] and [G.Iooss, P.I.Plotnikov, J.F.Toland. Standing waves on an infinitely deep perfect fluid under gravity. Arch. Rat. Mech. Anal. 177 (2005), 3, 367-478.], with the additional difficulty due to the above non zero rotation number. We show how to proceed to this inversion provided two diophantine conditions on the parameters are realized, allowing to transform the linear operator into a canonical pseudodifferential operator on the two-dimensional torus, with constant coefficients in the principal part, plus a regularizing operator. We prove the existence of bifurcating doubly-periodic non-symmetric waves for any values of the parameters ("1, "2) in a product of one-dimensional Cantor sets dense at 0.

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MS31

Viscous Shocks in the Destabilized Kuramoto-Sivashinsky Equation

We study stationary periodic solutions of the Kuramoto-Sivashinsky (KS) equation in the presence of an additional linear destabilizing term. In particular, we show the phase space origins of stationary 'viscous shocks' and related solutions, and discuss their appearance in related PDEs. These 'viscous shocks' arise in a reversible four-dimensional dynamical system as perturbed heteroclinic connections whose tails are joined through a reinjection mechanism due to the destabilizing term. We present numerical evidence that the transition from stable viscous shocks to the chaotic KS limit contains a rich bifurcation structure even within the class of stationary reversible solutions.

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MS32

Modulational Instability and Self-Trapping in Layered Optical Media

We investigate the propagation of optical pulses through a layered optical medium with periodic Kerr nonlinearity. The experiments show the appearance of additional instability bands beyond the first cutoff, in contrast to the single band of unstable wavenumbers in a uniform medium, with good agreement with theory and simulations. Additionally, the nonlinearity managed medium prevents collapse of the optical wave and supports the propagation of breathing self-guided beams.

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MS32

Vortices and Multi-pole Solitons in Photonic Crystals

We model the slowly varying electric field envelope of an extraordinarily polarized beam in two dimensional optically induced waveguide lattices with various geometries and nonlinearities. Recent results will be presented of the existence and stability of vortices and multi-pole soliton solutions with both focusing and defocusing nonlinearities in square, hexagonal, and honeycomb periodic geometries. Time permitting, well also discuss similar results of a BEC (Bose-Einstein Condensate) confined in a combination parabolic and periodic external potential.

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MS32

Bose Einstein Condensates in Periodic Potentials: Meanfield and Beyond

In this presentation we will shortly review the Heidelberg experiments on the dynamics of interacting matter waves i.e. Bose Einstein condensates, in periodic potentials. The observed phenomena such as gap solitons and macroscopic self-trapping are well described within the meanfield approximation of the Bose gas. The latest experiments on periodic potentials with single site resolution and number fluctuation measurements allow now for the first time to observe physics beyond the meanfield even for macoscopic occupation of single sites as high as 1000 particles. The experimental details will be presented and the connection to spin-squeezed quantum states will be elucidated.

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MS32

Consequences of Nonlinearity in Granular Metamaterials

Grains are macroscopic elastic objects. When two grains press against each other, they repel. This repulsive force is highly nonlinear and is described by the Hertz law (1881). The talk shall focus on how impulses initiated in granular alignments (with zero dissipation) propagate as solitary waves, on how these solitary waves interact with each other, and on the emergence of a new equilibrium-like phase where the equipartition theorem is not satisfied in granular chains that are held within fixed walls. In closing, the topic of shock absorption and of granular breathing will be discussed.

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MS33

Tsunami Wave Energy

In the vast literature on tsunami research, relatively few articles have been devoted to energy issues. A theoretical investigation on the energy of waves generated by bottom motion is performed here. We start with the full Euler equations in the presence of a free surface. Then we compare the results obtained through various approximations : nonlinear shallow water equations, Boussinesq systems. It is shown that dispersive effects only appear at higher order in the energy budget. The question of tsunami wave energy dissipation is discussed as well.

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MS33

Inverse Water Wave Modelling

The direct problem being the simulation of unidirectional waves generated by a waveflap at one end of a wave tank, as in hydrodynamic laboratories, the inverse problem is to find the required waveflap motion to produce a (realistic) desired elevation at a specified position. We use the AB-equation (Van Groesen and Andonowati 2007) for accurate simulations of various types waves and wavegroups. We will present preliminary results about the inverse problem.

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MS33

Orographic Generation of Two-dimensional Interfacial-wave Patterns

Experiments on finite amplitude interfacial waves forced by a surface-mounted obstacle towed through a two-layer rotating and non-rotating fluid are noted. When the Froude number F of the oncoming flow is close to unity and the obstacle height M relative to the layer depth is small, the flow is characterized by a transcritical similarity parameter $\Gamma = (F-1)M^{-2/3}$. The theory is verified numerically by comparing shock-capturing shallow water solutions and transonic small disturbance solutions.

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MS34

Quantum Description of X Waves

We provide a quantum description of X waves propagating in vacuum. Two kinds of quantum states of the electromagnetic field are introduced according to whether the field amplitude expectation value or the photo-detection probability density are required to be propagation-invariant pulses. The states of the first kind are introduced by exciting coherent states of different modes whose wave-vectors lie on a cone. The second kind of states are introduced as photon number eigenvectors so that single and multi-photon X waves are considered and their entanglement properties investigated.

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MS34

Perturbative and Non-perturbative Aspects of Optical Filamentation in Bulk Dielectric Media

Optical filament of ultrashort laser pulses in bulk dielectric media has been studied in all three phases of matter, including long distance propagation in air, also termed light string propagation, in water, and in glass. Optical filamentation leads to supercontinuum (SC), third-harmonic (TH), X- and O-wave formation and plasma channel generation. In this talk, I will present an interpretation of filament formation and subsequent SC generation processes in terms of three-wave scattering processes from a nonlinear potential. The spectrally-resolved far-field of the 3D propagating pulse reflects the essential structure of an attracting set and can reconstructed from a simple Born scattering approximation.

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MS34

X and Y Waves in the Spatiotemporal Instability of Spatially Localized Nonlinear Waves

The spatiotemporal instability of a continuous, self-guided wave in a dispersive, nonlinear optical medium, is seen to lead to the growth of two splitting and shocking Y-shaped pulses co-propagating with two linear X waves. This explains on a unified basis most of the phenomena observed spatiotemporal dynamics of a light filament.

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MS34

An Introduction to Subluminal and Superluminal Localized Solutions to the Wave and Schroedinger equations: Theory and Applications

A simple introduction is first presented to the ordinary Gaussian and to the Bessel waves, by separating the case of beams from the case of pulses; and an analogous introduction is afterwards presented for the Localized Waves (LW), pulses or beams. One aim of ours is stressing the different characteristics of the gaussian with respect to the Bessel waves, showing the important properties of the latter: Properties that may find application in all fields in which a role is played by a wave-equation (like electromagnetism, optics, acoustics, seismology, geophysics, gravitation, elementary particle physics, etc.). Some historical information is added. Moreover, various theoretical approaches are mentioned, which lead to nondiffracting of solutions to the wave equations (in unbounded or bounded media), together with a few applications of these waves. The different case of the Schroedinger equation is also mentioned. At last, we briefly investigate also the (not less interesting) case of the subluminal Localized Waves, and their connections with the superluminal ones. In particular, we recall the peculiar topic of zero-speed waves: Namely, of the localized fields with a static envelope ("Frozen Waves").

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MS35

Modelling Waves and Transport Using the Imperial College Ocean Model

We give a review of recent developments in the Imperial College Ocean Model, especially in the applications to the modelling of the shoaling of internal waves, tides and tsunamis. We also will describe a new family of finite element discretisations specially designed for geophysical fluid dynamics which are obtained by representing the velocity on discontinuous linear elements and the pressure on continuous quadratic elements. The elements have two combined properties: they are div-stable (only null eigenvector of gradient operator is the constant function), and they are able to represent geostrophic balance since the gradient of the continuous quadratic pressure lies in the space of discontinuous linear vector fields. The element also has mimetic properties, with div-curl being exactly zero. We illustrate the properties with linear and nonlinear Kelvin waves, and other examples.

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MS35

Statistical Steady State Mixing Measures and Effective Diffusivities

One measure of the mixing effectiveness of a velocity field advecting a passive scalar sustained by steady sources and sinks is the supression of scalar variance with stirring relative to that in the absence of stirring. This gauge naturally leads to the definition of effective, or "eddy" diffusion. We report rigorous results showing how the effective diffusion of statistically stationary homogeneous and isotropic flows (like ideal turbulence) depends on the flow and the source-sink distribution.

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MS35

Parameterization of Turbulent Transport of Reactive Tracers

In the last couple of decades, parameterization of geostrophic turbulence in ocean models has greatly improved. However, it has only marginally involved the case of turbulent transport of non conservative tracers. Here, the effects of mesoscale turbulence on reactive tracers are presented, together with simple parameterizations that account for the reactivity of the tracer. Applications to the modeling of marine ecosystems are discussed.

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MS36

Semi-classical Analysis and Instabilities for the Nonlinear Schrodinger Equation

We show how WKB analysis reveals instability mechanisms for the nonlinear Schrödinger equation (NLS). Two mechanisms are described: instability denying the uniform continuity of the flow of NLS in supercritical spaces, and instability at the semi-classical level. Taking the justification of WKB analysis for granted (we will say in which cases such a justification is available), we focus on the formal aspect of the mechanisms.

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MS36

Propagation of Waves in Periodic Nanotubes

We consider the propagation of waves in periodic nanomedia (nanoribbon and nanotube) in both an uniform magnetic field B and an external electric field. We describe all spectral bands and all eigenvalues (with infinite multiplicity, i.e., flat bands). We describe the spectrum as a function of $|B|$. For example, if $|B| \to r_n$ for some real $r_n, n \in Z$, then some spectral band shrinks into a flat band and the corresponding asymptotics are determined. Moreover, we consider the influence of external electric potential and we determine the asymptotics of the spectral bands both for small and large potentials.

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MS36

Asymptotic Stability of Lattice Solitons

We discuss orbital and asymptotic stability for 1-soliton solutions to the Toda lattice equations as well as small solitary waves to the FPU lattice equations in the energy space. Unlike analogous Hamiltonian PDEs, the lattice equations do not conserve momentum. Furthermore, the Toda lattice equation is a bidirectional model that does not fit in with existing theory for Hamiltonian system by Grillakis, Shatah and Strauss. To prove stability of 1-soliton solutions, we split a solution around a 1-soliton into a small solution that moves more slowly than the main solitary wave, and an exponentially localized part. We apply a decay estimate for solutions to a linearized Toda equation which has been recently proved by Mizumachi and Pego to estimate the localized part. We improve the asymptotic stability results for FPU lattices in a weighted space obtained by Friesecke and Pego.

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MS36

Instabilities in the Forced Periodic Non-linear Schrodinger Equation - Part I

The hierarchy of bifurcations framework is utilized and is developed in the PDE context to judiciously choose the initial profiles and parameter values that produce different types of chaotic solutions in the time-periodically forced, spatially periodic,one dimensional non-linear Schrodinger equation. Three different chaotic scenarios are identified: homoclinic chaos, hyperbolic resonance and parabolic resonance. The parabolic resonance mechanism is analysed and is shown to produce instabilities that can lead to transient spatial-temporal chaotic solutions.

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MS37

Solitons and Surface Waves in Optically Induced Periodic Structures

In this talk, I will present our recent work on discrete solitons and surface waves in optically induced periodic structures. I will discuss the possibility of generating linear and nonlinear surface/defect states in reconfigurable optical photonic structures. Our experimental study of nonlinear discrete trapping and nonlinear discrete surface states may be relevant for similar phenomena in periodic systems beyond optics, and the results from our work may have potential applications in optical sensors, light routing and switching.

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MS37

Optical Solitons in PT Potentials and Lattices

Beam dynamics in parity-time (PT) symmetric optical structures is examined in detail for both one and two-dimensional lattice geometries. It is shown that PT periodic structures can exhibit a host of unique characteristics stemming from the non-orthogonality of the associated Floquet-Bloch modes. Some of these features include double refraction, power oscillations and eigenfunction-unfolding as well as non-reciprocal diffraction patterns. In addition we investigate the effect of nonlinearity on beam dynamics in parity-time (PT) symmetric potentials. We show that a novel class of one- and two-dimensional nonlinear self-trapped modes can exist in optical PT synthetic lattices. These solitons are shown to be stable over a wide range of potential parameters. The transverse power flow within these complex solitons is also examined.

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MS37

Waves in Photonic Lattices: From Solitons to Anderson Localization

We review the recent progress on Anderson Localization effects in a periodic potential in the presence of both disorder and nonlinearity.

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MS37

Symmetry Breaking of Discrete Solitons and Its Suppression by Partial Incoherence

We study the symmetry breaking instability of discrete solitons with even parity in a 1-D waveguide array, and find that such instability can be suppressed by adding spatial incoherence. This is true for both staggered and unstaggered modes.

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MS38

Particle Rare Event Stochastics Simulations

The correspondence between Feynman-Kac path particle measures, and event restrictions of stochastic processes is a modern and extremely powerful tool in the analysis of rare events probabilities. In this interpretation, the occupation measures of a class of particle genealogical trees give a precise description of the elementary events leading the process to enter in such critical events. We review the mathematical and physical foundations of these particle rare event stochastics simulation methods and we discuss some applications to polarization-mode dispersion problems.

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MS38

Hodographic Vortices

Optical vortices arise as electric field phase dislocations in linear and nonlinear optics. We show that in nonlinear optics helicoidal vortices are a universal and purely geometric phenomenon. They "survive" in the geometric optics limit and do not depend on the form of the nonlinearity. Moreover, the analysis of the phase equations on the hodograph plane leads to a family of generalized vortex-type phase dislocations whose structure, in spite of the standard helicoidal vortex, results to be sensitive to the nonlinear response.

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MS38

Optical Fiber Systems Are Convective Systems

We report theoretical and experimental demonstration of convective regime in a fiber ring cavity. The asymmetry required to observe this regime is induced by the slope of the group velocity dispersion. Except optical fibers with perfect flat dispersion, these systems are always convective. A saddle point analysis is performed and confirmed the key role played by the slope of the dispersion. We experimentally validate the occurrence of convectif regime in such cavities.

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MS38

Multichannel Nonlinear Signal Processing: Recent Progress in All-optical Regeneration of WDM Signals

This talk will survey our recent work (2005-2007) on achieving simultaneous multichannel operation by a 2R all-optical regenerator. We will review the principle of the single-channel device, proposed in 1998 by P. Mamyshev, and show that the regeneration is enabled by strongly nonlinear propagation of an intense pulse in a dispersive fiber. On the other hand, those very nonlinear effects that enable single-channel regeneration, lead to debilitating distortion of a multichannel signal. We will then explain a modification that allows one to process multiple channels simultaneously. A key component enabling this modification is a periodic group delay device, which greatly alleviates interchannel interaction by tailoring group-velocity dispersion in a certain manner. We will present results of numerical simulations demonstrating eye opening improvement for 10 and 40-Gb/s channels, as well as our preliminary experimental results for 10 Gb/s signals. Finally, we will briefly mention results of multicanonical Monte Carlo simulations describing the impact of a single Mamyshev-type regenerator on the bit error rate of a signal degraded by optical noise.

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MS39

Negative Filament Tension of Scroll Waves in a Model of Cardiac Tissue

Scroll waves are vortices that occur in three-dimensional excitable media. Scroll waves have been observed in a variety of systems including cardiac tissue where they are asociated with cardiac arrhythmias. The disorganization of scroll waves into chaotic behaviour is thought to be the mechanism of ventricular fibrillation. One of the possible mechanisms of scroll wave instability is negative filament tension, typically related to ischemia conditions. We have studied the negative filament tension for simple models of excitable media and for the Luo-Rudy model, widely used in cardiac electrophysiology.

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MS39

Electrical Model of Rabbit Heart for the Study of Defibrillation

I will present a realistic numerical model of the rabbit heart. It includes both the three dimensional geometry and the orientation of the fibers. Also both intra- and extracellular electrical potentials are considered as model variables. This model generalizes previous models that only dealt with membrane potential. In doing so, this model allows for studying very large electrical potentials that are applied during defibrillation events. Our future objective is the design of better strategies for resetting the heart while entering a fibrillation episode.

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MS39

Properties of Cardiac Discordant Alternans

We study the mechanisms for initiation of spatially discordant alternans by numerical simulations of an ionic model spatially distributed in a one-dimensional cable and in an anatomical model of the rabbit heart. The effects of CV-restitution, ectopic beats, and the role of spatial gradients of electrical restitution properties are investigated. The mechanism of, and the conditions for, initiation are determined based on an iterated map analysis of beat to beat changes of APD. This analysis leads to the definition of a vulnerable window for initiation of discordant alternans.

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MS39

Termination of Cardiac Arrhythmia Using Low-energy Far-field Stimulation

Cardiac fibrillation is the state of extremely rapid and dysynchronos electrical excitation of the heart. These complex wave patterns correspond to heart rhythm disorders, which are the leading cause of death in the industrialized world. The control and termination of cardiac arrhythmias is a major challenge. Low frequency arrhythmias (up to 4 Hz) can be terminated gently and effectively by pacing from a single site only. It has been demonstrated, that the termination of high frequency - and often lethal - arrhythmias is possible, but requires a very large number of pacing sites. Pacing from many sites could not be achieved, because installing and connecting many leads may damage the contracting heart. Here we show, that multisite pacing can be achieved non-invasively by applying a pulsed low-energy electric field to the cardiac tissue. We found in canine heart preparations that such a pulsed far-field may result in the emission of waves from tissue heterogeneities, which are anatomical objects of various size present within the cardiac muscle. How many of these objects may act as a wave source depends on the electric field strength. We demonstrate that pulsed far-field stimulation can be used to terminate cardiac fibrillation.

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MS40

Effects of the Free Surface on Nonlinear Internal Waves

In this work, we study the propagation of large amplitude internal waves in two-layer flows by considering strongly nonlinear long wave models. Both rigid-lid and free-surface are set for the upper boundary and internal solitary-wave solutions for the two configurations are compared. Shear instability at the interface is also examined with and without the hydrostatic assumption and, in particular, free surface effects are discussed in detail.

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MS40

Strongly Nonlinear Periodic Internal Waves in Two Fluids Systems

Internal waves are an important component of geophysical fluid dynamics, because stratification is inherent to near equilibrium ocean and atmosphere. Because of the relatively low viscosities and potential energy penalties experienced by fluid parcels displaced by natural forcing agents, such as winds and tides, internal waves can in fact occur with relatively large amplitudes, as recent improvements in instrumentation and observational techniquesin the ocean have revealed. We focus on the simplest set-up capable of supporting internal wave motion, that of a two-layer inviscid and incompressible fluid of homogenous densities between two infinite horizontal plates, and extend the results of a previously derived model capable of handling strong nonlinear regimes to the case of periodic travelling wave motion. For this motion, the question of what constitutes a minimal set of physical parameters for uniqueness of a periodic solution to the full Euler system has not been completely elucidated, and various alternatives have been proposed. The minimal set and uniqueness issue is still somewhat controversial, even for its single layer counterpart of surface periodic irrotational waves. We explore some of these alternatives in the framework of our model, and discuss their relation to the physical processes by which the waves are generated.

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MS40

Hyperfast Numerical Modelling of the Euler Equations

I consider three integrable equations for developing a numerical model of the Euler equations to arbitrary order: the KP equation, the 2+1 Gardner equation and the 2+1 CH equation. Each of these integrable equations is modeled with Riemann theta functions plus a Hirota-type transformation. A new approach for computing theta functions is employed which is substantially faster than other methods. I further correct the integrable equations for asymptotic integrability using near identity transformations, and add perturbations for the nonintegrable terms. The new approach is three orders of magnitude faster than the commonly used higher order methods. I give numerical examples and derive analytical solutions of three types of rogue waves which arise naturally in the formulation.

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MS40

Effects of Shore Reflection on Bragg Reflection

A series of bottom corrugations (or natural sand bars) can have a cooperative effect on incident water waves, called Bragg resonance. Here we discuss the significance of the ordinary shore reflection on resonant reflection by a finite patch of corrugations. A comparison of the asymptotic and exact solutions is made for standing waves in a tank with corrugated bottom, showing the importance of the fast varying flow components at boundaries.

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MS41

Nonlinear Stability of Time-periodic Viscous Shocks

Time-periodic shocks in systems of viscous conservation laws are shown to be nonlinearly stable. The result is obtained by representing the evolution associated to the linearized, time-periodic operator using a contour integral, similar to that of strongly continuous semigroups. This yields detailed pointwise estimates on the Green's function for the time-periodic operator. The evolution associated to the embedded zero eigenvalues is then extracted. Stability follows from a Gronwall-type estimate, proving algebraic decay of perturbations.

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MS41

Breathers in a Three-component Reaction-diffusion System

In this joint work with Peter van Heijster and Arjen Doelman, we carry out a stability analysis of stationary one-pulse and two-pulse solutions of the three-component R-D model of H.-G. Purwins, and also studied extensively by Y. Nishiura. It is an activator-inhibitor system with two inhibitors. Using the fast-slow decomposition of the Evans function and the NonLocal Eigenvalue Problem method, we analytically identify the bifurcations and instabilities of these solutions, focusing among others on the Hopf bifurcation to breathing pulses. There are also novel features of the Evans function decomposition due to the presence of the second slow species.

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MS41

Persistence of Inviscid Roll-waves in the Satin Venant Equations

In that talk, I will discuss the persistence of roll-waves solutions of the shallow water. These are discontinuous periodic travelling waves, shocks being Lax shocks. Persistence here means that starting with an initial condition that has the same structure as the roll-wave, the Cauchy problem is well posed. The main issue is the presence of an infinite number of shocks: through a suitable change of variable, all the shocks are fixed and one can use the classical tools used for the stability of shocks.

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MS41

Semi-strong Interaction of Time-period Solutions in Reaction-diffusion Systems

We present an overview of the Renormalization Group approach recover dynamics of interacting coherent structures in singularly perturbed reaction diffusion systems. In the semi-strong limit some components of the pulse solution are localized, while other components do not relax to equilibrium between the localized pulses. These non-localized pulse components induce leading order changes in pulse velocity, stability, and profile. We present a general approach

to these systems which has broad applicability.

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MS42

Travelling Waves in Strongly Inhomogeneous Media: Propagation and Transmission

The existence of traveling wave solutions of an one-dimensional wave equation with variable speed is studied. Such solutions can be found provided the variable wave speed satisfies certain conditions. The solution of the Cauchy problem is obtained. The process of wave reflection and transmission through a zone with a gradient jump in the wave speed is analyzed in detail. Possible applications of obtained solutions to the long wave runup problems are discussed.

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MS42

Fission of a Weakly Nonlinear Interfacial Solitary Wave at a Step

Transformation of an interfacial soliton in an ideal two-layer flow over a step is studied. In the vicinity of the step the wave transformation is described in the framework of the linear theory, and the coefficients of wave reflection and transmission are calculated. Far from the step, the wave dynamics is described by the Korteweg-de Vries equation and the soliton amplitudes are calculated. Effects of cubic nonlinearity are studied in the framework of the Gardner equation.

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MS42

Do Free Surface Potential Gravity Waves on the Surface of Deep Fluid Form and Integrable System?

The question formulated in the title of this talk is a conjecture. However, there are very strong reasons to believe that the conjecture is correct. Let us list three of them: (1) Euler equation for potential flow of deep incompressible fluid could have extra constants of motion. The number of constants is finite and depends on initial data. However, this number can be arbitrary large; (2) Certain coefficient functions describing processes of nonlinear wave interaction are identically equal to zero. (3) Giant "breathers", analogs of envelop solitons do exist up to very high level of steepness (up to $mu = 0.7$ or more.)/.This is a very natural explanation for formation singular freak waves. The results presented in my talk are supported by analytical considerations and massive numerical simulations.

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MS42

Resonant Excitation of Trapped Waves in the Oceanic and Atmospheric Waveguides, and Formation of Coherent Structures

We show that resonant interactions between free waves and trapped waves, or between free waves, trapped waves and mean current in the waveguide provide an effective mechanism of excitation of waveguide modes. Within the simplest one- or two-layer rotating shallow water models we demonstrate how this mechanism works for coastal and topographic waveguides in the ocean, and the equatorial waveguide in the ocean and atmosphere. The modulated amplitudes of the excited waveguide modes obey the Ginzburg-Landau type equations for dispersive waves, and forced Burgers equation for non-dispersive waves, and form coherent structures.

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MS43

Dispersive Shock Waves in Bose-Einstein Condensates and Nonlinear Optics

Analogy between superfluid dynamics and propagation of light beams through nonlinear media is well known and quite suggestive. We use this analogy for developing the theory of dispersive shocks observed in evolution of Bose-Einstein condensates (BECs) and propagation of intensive light beams through photorefractive media. Two typical BEC situations are considered: (i) "blast" dispersive shocks and (ii) their formation in a supersonic flow of BEC past an obstacle. Their optical counterparts correspond to formation of oscillating structures due to interplay of self-focusing nonlinearity and light diffraction for different conditions of the light beam propagation. Main characteristics of shocks are calculated analytically and these analytical

results are confirmed by numerical simulations.

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MS43

Electromagnetic Enhancement in Transition Metamaterials

We predict resonant enhancement of electromagnetic waves propagating at oblique incidence in metamaterials, with dielectric permittivity and magnetic permeability gradually changing from positive to negative values. This phenomenon occurs for both transverse magnetic and transverse electric polarizations near zero-index point.

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MS43

Instability of Incoherent Light in High Temperature Plasma

We develop the statistical theory of the stimulated Brillouin backscatter (SBS) instability of a spatially and temporally partially incoherent laser beam in for laser fusion relevant plasma. We found a new regime of SBS which has a much larger threshold than classical threshold of coherent beam in the long-scale-length laser fusion plasma. Instability is collective because it does not depend on the dynamics of isolated hot spots of laser intensity, but rather depends on averaged beam intensity and bandwidth. We identified convective and absolute instability regimes. The threshold of convective instability is inside the typical parameter region of National Ignition Facility designs. Well above incoherent threshold the coherent instability growth rate is recovered.

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MS43

Numerical Modelling of Femtosecond Laser Bullets

Nonlinear propagation of ultrashort laser pulses is an underlying physical phenomenon behind femtosecond micromachining. It exhibits an extremely complex dynamics of laser bullets that is pulses limited in space and time. Typically the laser peak intensity required for material modification exceeds the ionization threshold and electron-hole plasma is created. We present the results of multiscale modelling of femtosecond laser bullets in the presense of such plasma in the framework of extended Nonlinear Schroedinger equation compared with full-vectorial Maxwell's equations.

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MS44

An Overview of Self-replicating Pulses

Self-replication of different types has been observed in various models mainly in one and sometimes more spatial dimensions, and real experiments. The models range from reaction-diffusion systems of two to four components, models with cross-diffusion, non-linear and time-dependent diffusion, to coupled complex Ginzburg-Landau equations. We give an overview of these observations and results, and classify types of self-replication.

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MS44

Oscillating Kinks in Forced Oscillatory Media: A New Type of Instability

Instabilities of propagating localized solutions, so called phase kinks, are studied in a one-dimensional spatially extended and dissipative system. They are observed in periodically forced oscillatory media at 1:1 resonance, where phase kinks have close similarities to pulses in excitable media. Considering the periodically forced complex Ginzburg-Landau equation, different dynamical regimes, characterized by the kink behavior, are described: Stable kinks, propagating oscillating kinks and replication of kinks are possible. Mechanisms for transitions between these regimes are discussed within the framework of a bifurcation analysis of the kink profiles.

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MS44

Anomalous Dispersion, Breathing Pulses and Backfiring in a Chemical Reaction System

An interesting example of a chemical excitable system is the 1,4-cyclohexanedione Belousov-Zhabotinsky (CHD-BZ) reaction. The spatial extended reaction-diffusion systems shows traveling waves of excitation as well as wave and spiral instabilities. Experimental observations of wave phenomena in pseudo-one, pseudo-two and three dimensional CHD-BZ systems are presented. Specifically, we discuss different types of anomalous dispersion relations, oscillatory and wave-emitting excitation pulses, spiral and scroll wave nucleation scenarios, and negative filament tension.

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MS44

Self-Replicating Localized Spot Solutions for Reaction Diffusion Models in Two Space Dimensions

We analyze the dynamical behavior of multi-spot solutions in a two-dimensional domain Ω for certain two-component reaction-diffusion models in the singularly perturbed limit of small diffusivity ϵ for one of the two components. A formal asymptotic analysis, which has the effect of summing infinite logarithimic series in powers of $-1/\log\epsilon$, is used to derive an differential algebraic system of ODE's characterizing the slow dynamics of the spot locations. By numerically examining the stability thresholds for a single spot solution, a specific and simple criterion is formulated to theoretically predict the initiation spot-replication events. The analytical theory is illustrated for spot patterns in a square and a disk and the asymptotic theory is compared with full numerical results computed from an adaptive grid PDE solver.

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MS45

Some Stability Results for a Semilinear Dirac Equation

We study the behavior of perturbations of small nonlinear Dirac standing waves. We assume that the linear Dirac operator of reference $H = D_m + V$ has only one double eigenvalue and that degeneracy is due to a symmetry of H (theorem of Kramers). In this case, we can build a small 4-dimensional manifold of stationary solutions tangent to the eigenspace of H. We show that any H^s perturbation of stationary solutions, with $s > 2$, stabilizes towards a standing wave. For localized perturbations, we obtain a nonlinear scattering result.

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MS45

Schroedinger Map and Landau-Lifshitz Dynamics

The Landau-Lifshitz equations of ferromagnetism, are a geometric (and hence nonlinear) version of a linear Schroedinger equation with dissipation, including as special cases the Schroedinger map problem, and the harmonic map heat-flow. Asymptotic behaviour and (possible) singularity formation in finite energy solutions remain poorly understood. We describe some results of an ongoing project with Meijiao Guan, Kyungkeun Kang, and Tai-Peng Tsai to understand these issues.

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MS45

Stability of Thomas-Fermi Condensates in Parabolic Potentials

We consider the Gross-Pitaevskii equation with a parabolic potential in the hydrodynamics limit, when a small parameter appears in front of the dispersive term. Ground states and vortices are considered in the Thomas-Fermi approximation. We compute eigenvalues of the linearized Gross-Pitaevskii equation in this limit and prove persistence of these eigenvalues. Results on existence and stability of the relevant solutions are corroborated by numerical computations.

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MS45

Instabilities in the Forced Periodic Non-linear Schrodinger Equation - Part II

The hierarchy of bifurcations framework is utilized and is developed in the PDE context to judiciously choose the initial profiles and parameter values that produce different types of chaotic solutions in the time-periodically forced, spatially periodic,one dimensional non-linear Schrodinger equation. Three different chaotic scenarios are identified: homoclinic chaos, hyperbolic resonance and parabolic resonance. The parabolic resonance mechanism is analysed and is shown to produce instabilities that can lead to transient spatial-temporal chaotic solutions.

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MS46

Two and Three Dimensional Self-confinement in Semiconductor Resonators

We study the 3D dynamics of the coherent field in a semiconductor microresonator in monolithic and non-monolithic configurations. The focus is posed on the self-assembly of spatial structures in the field profile.

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MS46

Cavity Soliton Dynamics

Dissipative optical solitons in semiconductor cavities are of great current interest. The talk will examine both intrinsic dynamics (stability, spontaneous motion) and the dynamics of their interaction with external influences, such as other solitons, material defects, and imposed forces. Both coherently-driven and self-excited (cavity soliton laser) systems will be considered.

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MS46

Cavity Solitons and Patterns in Optically-pumped V(E)CSELs

We investigate the spatio-temporal dynamics of optically pumped Vertical Cavity Surface Emitting Laser and their ability to sustain pulsed cavity solitons. We report first on the stability analysis of an extended cavity with intracavity optics and eventually a saturable absorber mirror with the aim of preserving a high Fresnel number and a controlled level of diffraction. A comparison with our experimental observations is performed. A second series of experiments is reported with compact cavities combining gain and saturable absorption sections. Bistability and pulsed regimes are observed and analyzed. The possibility of pulsed cavity soliton observation is discussed.

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MS46

Effects of Phase and Intensity Gradients on Localized Structures

We study the effects of phase gradients on the generation and motion of localized structures, also called cavity solitons (CS). We show that phase symmetry does not allow the generation of CS. On the other hand the effects of controlled phase gradients may be very useful to control motion and speed of CS. We experimentally show the principle of operation of a shift register and a force microscope.

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MS47

Statistical Light Mode Dynamics of Short Pulses

Passive mode locking in lasers that provides the basis for ultra short light pulses generation is a process of spontaneous ordering of interacting laser modes. Decoherence by cavity noise is a disrupting factor for mode locking that injects entropy into the cavity. The thermodynamic phase transition from cw to mode locking is captured by statistical light mode dynamics (SLD) - the stochastic theory of many interacting modes. I will show how SLD enables the explanation and prediction of the mode locking transition as well as new phenomena like multi-pulse mode locking and critical phenomena of light.

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MS47

Optical Soliton Molecules in Nonlinear Dissipative Systems

Compared to conservative systems, dissipative nonlinear systems have unique properties. Many of them allow the formation of stable pulse complexes, analogous to molecules although they live in an open environment providing energy. Optical soliton molecules are found numerically in cubic-quintic Ginzburg-Landau models, and confirmed experimentally in mode-locked fiber lasers. Different types of soliton molecules are presented, from self phase-locked soliton pairs and triplets to vibrating soliton molecules, from both numerical and experimental points of view.

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MS47

A Generalized Perturbation Theory for Arbitrarily-Shaped Pulses in Modelocked Lasers

A modelocked laser pulse is characterized by the pulse's energy, central time, central frequency, and phase. The response of these five parameters to perturbations depends on the pulse shape as a function of position along the laser cavity. Traditional perturbation theory assumes that the pulses are hyperbolic-secant-shaped. This assumption is not accurate for modern-day laser pulses. In this work, we establish a perturbation theory that is valid for pulses with any shape.

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MS47

Ensembles and Interactions of Fiber-optic Solitons

After years of research, temporal optical solitons are now actually utilized in commercial optical telecommunications systems. In spite of the tremendous success of optical information transmission, data rates soon approach the fundamental limit of the binary data-carrying capacity of optical fiber. Concepts beyond individual soliton pulses may prove helpful in pushing, or working around, that limit. Several types of soliton compounds will be discussed, including soliton molecules which were experimentally demonstrated recently.

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MS48

Nonlinear Stability of Wavefronts in Combustion of High Density Liquid Fuels

I will discuss two aspects of the stability analysis of fronts in combustion of high density liquid fuels: the relation of the spectrum of the front to the spectrum in the limiting case, which is done by means of construction of the Stability Index Bundles (joint work with C.K.R.T. Jones), and the nonlinear stability of the front, in a weighted norm, when the fuel thermodiffusivity is small and the spectral information is not definitive.

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MS48

Evans-function Computations for the Majda Model

In this talk we report on work in progress related to the spectral stability of combustion waves in Majda's model for reacting fluids. The approach is based on a combination of asymptotic ODE techniques and numerical Evans-function computations.

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MS48

Stability of Fronts in Gasless Combustion

For gasless combustion in one space dimension, we show that the physical combustion front has a type of nonlinear stability, in a space of perturbations that are bounded behind the front and decrease exponentially ahead of the front, provided the linearized operator has no eigenvalues in the right half-plane besides a simple zero eigenvalue. Simplicity of the zero eigenvalue is shown using the Evans function. Factors that complicate the analysis are: (1) the linearized operator is not sectorial, and (2) in a space in which the linearized operator has good spectral properties, the nonlinear term is not small. I will explain why the result makes good physical sense.

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MS48

Galloping Instability of Detonation Waves

We show that transition to longitudinal instability of strong detonation solutions of reactive compressible Navier–Stokes equations is generically associated with Hopf bifurcation to nearby time-periodic "galloping', or "pulsating', solutions, in agreement with physical and numerical observation.

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MS49

Strongly Nonlinear Internal Solitary Waves Interacting with Bottom Topography

Packets of large amplitude internal solitary waves have been observed in many coastal regions around the world. These highly nonlinear wave packets are typically generated by the interaction of stratified tidal flow with strong topographic features. Here we study the propagation of such waves interacting with bottom topography using a strongly nonlinear internal wave model for a two-layer system.

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MS49

Head-on Collision of Steep Solitary Waves and the Rayleigh-Taylor Instability?

The instability due to the head-on collision of two steep solitons or the run-up of a steep soliton on a vertical wall is investigated. A series of numerical simulations is performed for various values of the dimensionless amplitude. The initial solitary waves are computed by using the Tanaka's algorithm. For very high values of the dimensionless amplitude it found that an instability develops in the vicinity of the crest of the wave during the collison. The question is: Is it a Rayleigh-Taylor instability?

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MS49

Falling Spheres in Stratified Fluids

We explore the motion of heavy spheres falling through a sharp salt stratified fluid layer in which an intriguing levitation phenomena is observed: the heavy sphere experiences a transient levitation in which the sphere descends through the sharp transition, stops, and rises back into the layer before ultimately returning to descent. Careful measurements will be presented showing the sphere residence time. The hydrodynamics, which involves a strong coupling between variable density fluid, and moving solid boundary, entrained, turbulently mixed fluid, and strong internal waves will be discussed. Time permitting, we will discuss exact and asymptotic calculations in potential flows relevant to this geometry.

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MS49

Unstable Internal Waves

Recent advancements in observational techniques have revealed that internal gravity waves are an ubiquitous phenomena in the ocean and in the atmosphere. In particular, internal waves propagating in a stratified ocean have been observed and reported to have large amplitudes. Understanding the breaking mechanisms of these waves is crucial for explaining mixing and transport phenomena within the ocean. As experimental observations show, for near two layer stratification, waves become unstable in large amplitude regimes and the wave-breaking closely resembles Kelvin Helmholtz shear instability originating in the maximum displacement of the pycnocline region. The instability is modulated by the stream-wise variation of the shear. We simulate numerically the generation and propagation of solitary waves starting from a step function initial condition and monitor the wave-induced shear instabilities. A conservative projection method for the variable density Euler equations is implemented in this scope. The code is validated against experimental data as well as theoretical results. In an effort to elucidate wether the instabilities are an intrinsic property of the wave or they are induced by the experimental generation, we study the time evolution of traveling wave solutions.

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MS50

Homogenization of Scalar Conservation Laws with Vanishing Viscosity

We study the asympotic behaviour of a hyperbolic scalar conservation law with highly oscillating coefficients. When the initial data is well-prepared, that is, when it is adapted to the micro-structure dictated by the flux of the conservation law, we prove a strong convergence result. In general, the limit system is of kinetic type, and cannot be reduced to a conservation law. We also tackle a related parabolic problem with vanishing viscosity; in this context, we are able to prove a convergence result without any assumption on the initial data. In particular, when the initial data is ill-prepared, there is an initial layer during which the solution adapts itself to match the profile dictated by the environment.

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MS50

Unstable Periodic Orbits and Stationary Points of Barotropic Atmospheric Model

Unstable periodic orbits (UPOs) are an important feature of chaotic dissipative systems. For some of chaotic systems like Anosov or Axiom A systems UPOs are dense on the system attractor so that any trajectory of the system can be approximated by some orbit with any given accuracy. As a result statistical characteristics of a system can be quantified in terms of UPO characteristics. Atmospheric systems are dissipative and chaotic but likely do not have Axiom A property. In this study we try to understand to what extent UPOs of simple atmospheric system approximate its dynamics and statistics. The system under consideration is a Galerkin approximation for barotropic vorticity equation on a rotating sphere with T12 and T21 truncations. With the help of damped Newton and Gauss-Newton methods we were able to find a large set of the system UPOs and stationary points. It was shown that average state of the system as well as its second order statistics (variance and leading EOFs) can be calculated by UPOs with very high accuracy. Other system properties like Kaplan-Yorke attractor dimension and number of positive Lyapunov exponents can also be reconstructed using UPOs. These results suggest that UPOs form a skeleton of the system attractor and may be important in understanding model dynamics.

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MS50

Evans Function for Periodic Waves in Infinite Cylindrical Domain

We consider an elliptic equation with periodic boundary conditions and define a stability index with Evans function analogous to one by Gardner & Zumbrun. The key for defining the index is exponential dichotomies for the system. This system has infinite dimensional stable and unstable spaces. We use Galerkin approximation to reduce down these dimensions to finite and show persistence of dichotomies. This work generalizes the work of Sandstede & Scheel to 2-dimensional patterns. To determine instability, both the relative orientation of the linear stable and unstable subspaces and the sign of the momentum play an important role.

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MS50

Spectral Stability of Periodic Solutions of Semi-discrete Conservation Laws

We consider dispersive semi-discretization of scalar conservation laws. Space-periodic travelling waves do exist. We study their dynamical stability and relate this property to the Hadamard well-posedness of a homogenized system.

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MS51

Implementation of Virtually Non-dissipative Links in Optical Fibre

We will review some of the recent advances on the implementation of transparent transmission links using ultra-long Raman laser cavities in optical fibre, and discuss the opportunities offered by these virtually ideal communication links in areas such as signal processing.

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MS51

Dissipative Nonlinear Structures in Fiber Optics

Optical fiber materials exhibit a nonlinear response to strong electric fields, such as those of optical signals confined within the small fiber core. Fiber nonlinearity is an essential component in the design of the next-generation of advanced optical communication systems, but its use is often avoided by engineers because of its intractability. The deployment of nonlinear technologies in fiber optics offers new opportunities for the design of photonic systems and devices. In this talk, we report on our recent progress in theoretical and computational studies of dissipative nonlinear structures generated in optical fibers. Both a mathematical theory of such compact, strongly localized solitary waves and their applications to the design of innovative photonic systems and data processing devices in optical communications will be discussed.

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MS51

Self-organized Dissipative Light Bullets

The diffraction and dispersion of three-dimensional optical pulses need to be compensated by saturating nonlinearity, in order to form light bullets. We demonstrated that only cross compensation between saturating nonlinearity excess, loss, and gain maintains such dissipative solitonic structure in stable dynamic equilibrium. A general stability criterion is established rendering a large domain of attraction. Following our numerical simulations, quite asymmetric (as in experiments) inputs from this domain always self-organize into very robust light bullets.

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MS51

Localized Beating in Low-dispersion All Fiber Ring-cavity

Close to zero-dispersion wavelength in fibre cavities, we show that the presence of a fourth-order dispersion coefficient gives rise to a degenerate modulational instability where two separate frequencies simultaneously appear. Another consequence of fourth-order dispersion is that the stationary state regains stability at large pump powers. Finally, when the two dynamical frequencies are sufficiently close together, we demonstrate a new dynamical behavior that consists of localized beating. Realistic experimental parameters are assumed.

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MS52

Analytic Description of Plane Wave Propagation in Metamaterials

In order to improve the understanding of wave propagation in dielectric media with regular metallic inclusions (i.e. metamaterials), a simple analytical model has been developed within the framework of the macroscopic Maxwell Equations. Evident requirement in this case is that the sizes of the metallic inclusions should be much smaller than the wavelength. In spite of the fact, that this requirement is usually not fulfilled in the experiments, it is methodologically interesting to create a respective model. Basically, the model gives us a tool for the calculation of the multipole moments of the plasmon oscillations taking place in the metallic inclusions. After substituting the multipole moments into the macroscopic Maxwell Equation, the model becomes self-consistent. The rather complicated plasmon dynamics in the metallic inclusions as well as the coupling between them is modelled by a set of harmonic oscillators. The generating symmetric and anti symmetric oscillation modes, that are supposed to be directly responsible for the effective permittivity and permeability of the metamaterial, are described. In our work dispersion relations for a plane wave have been calculated. The dispersion relations have been compared with the ones, obtained through FTDT calculations. A possible way for the electric and magnetic constants introduction has been suggested. Criteria for metamaterial effect are presented. Different types of losses (reversible and irreversible) and principally different origins of magnetic properties of quantum objects are underlined. Validity criteria and applicability limitations of the developed model are discussed. A natural way of nonlinearity introduction through the quadrupole and magnetic dipole moments is discussed.

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MS52

Nonlinear Spatio-temporal Characteristics of the Optical Field Near an Interface were the Index of Refraction Changes Sign

We consider temporal nonlinear light dynamics near an interface where the index of refraction continuously changes its sign in a continuous fashion. It is known that near this interface, where n=0, the values of the electric and magnetic field components experience a significant enhancement, which may lead to a strong nonlinear response. We study spatio-temporal effects due to such a field enhancement induced by the presence of the Kerr nonlinearity. In particular, we investigate nonlinear transmission and loss characteristic at this interface.

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MS52

Interaction of Short Electromagnetic Waves with a Thin Film: A Simple Model

We analyze the interaction of short electromagnetic waves with a thin film. The model for the medium can be classical (Duffing oscillator) or quantum (Bloch equations). In the former case the problem can be described by a Lagrangian involving the field energy in terms of the vector potential and a Landau free energy for the polarisation. The free energy of a ferroelectric has two stable equilibria while for a paraelectric it has only one. We examine the linear limit using scattering theory and analyze the switching between equilibria. When the medium is described by the Bloch equations, the field matter model has less symetries. We review this case and present numerical results.

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MS52

Nonlinear Dynamics of Parabolic Pulse Solutions to the Dissipative Whitham Equations and Applications to Supercontinuum Guided Wave Light Sources

Wave-breaking free optical pulse propagation in nonlinear, weakly dispersive optical fiber amplifiers may be described in terms of a dissipative extension of the Whitham equations. In the conservative case such equations permit to describe NRZ pulse propagation in normally dispersive optical fibers. We provide analytic solutions for the evolution of parabolic pulses, which are the stable attractors of the amplifier. We experimentally investigate applications to optical supercontinuum generation with a properky designed dispersion decreasing fiber.

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MS53

A Mean-field Model in Price Formation and Dynamical Equilibria

We present the analytical study of a free boundary value problem for a nonlinear system of diffusion equations. The model has been very recently proposed by J.M. Lasry and P.L. Lions as a new mean-field approximation for price formation. The price of the traded good results from a dynamical equilibrium and corresponds to a free boundary.

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MS53

Regularity of Solutions to the Navier-Stokes Equations Evolving from Small Initial Data in a Critical Space

In this talk we will present a regularity result for solutions to the Navier-Stokes equations evolving from small initial data in a critical space in $\mathbf{R}^n$. We prove that under certain smallness condition on the initial data in BMO^{-1}, the solutions of the Navier-Stokes equations constructed by Koch and Tataru are more regular. As a consequence, we obtain a decay estimate in time for any space derivative, and space analyticity of the solution. Also as an application of our regularity theorem, we prove a regularity result for self-similar solutions.

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MS53

Long Time Existence for the Rapidly Rotating Shallow-water and Euler Equations

We study the stabilizing effect of rotational forcing in the nonlinear setting of two-dimensional shallow-water and more general models of compressible Euler equations. The pressure-less version of these equations admit global smooth solution for a large set of sub-critical initial configurations. But what happens with more realistic models, in the presence of pressure? it is shown that when rotational forcing dominates the pressure, it prolongs the life-span of such sub-critical solutions, for a time period dictated by the ratio delta=Rossby number/squared Froude number. Our study reveals a "nearby' periodic-in-time approximate solution in the small delta regime, upon which hinges the long time existence of the exact smooth solution. These results are in agreement with the close-to periodic dynamics observed in the "near inertial oscillation' (NIO) regime which follows oceanic storms.

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MS53

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MS54

Exact Travelling Wave Solutions for a Generalized Davey-Stewartson System

A system of three coupled nonlinear equations which is called generalized Davey-Stewartson equations is considered and some special solutions of them are investigated. To this aim, travelling wave solutions of the generalized Davey-Stewartson equations are given by using two different methods, i.e., by Jacobian elliptic functions and a tanh method. Besides, some special solutions of the generalized Davey-Stewartson equations are also established by using a variable separation approach developed for nonlinear equations.

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MS54

Existence and Stability of a Planar Traveling Wave in a Combustion Model

It is shown that thin solid, for an example, paper and polyethylene sheets, burning against oxidizing wind develops fingering patterns. The oxidizing gas is supplied in a uniform laminar flow, opposite to the directions of the front propagation and the flow velocity of oxygen is controlled. When the velocity is decreased, the smooth front develops a structure which marks the onset of instability. As it is decreased further, the peaks are separated by cusp-like minima and a fingering pattern is formed. Similar phenomena have been observed in a micro-gravity experiment in space. In this talk, we propose a phenomenological model described by the following reaction-diffusion system for the temperature, the density of paper, the concentration of the

mixed gas and show the existence and stability of a traveling wave solution for the system in a cylindrical region.

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MS54

Traveling Wave for a Thin Liquid Film with Surfactant on an Inclined Plane

We show the existence of traveling wave solutions via geometric singular perturbation theory for a lubrication model for a surfactant-driven flow of a thin liquid film down an inclined plane. We construct the solutions in certain singular limits, and then we extend the parameter regimes where the solutions exist.

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MS54

Nanostructured Energy Conversion: Pore Formation in Polymer Electrolytes

Polymer electrolytes are examples of a functionalized material. Energy, in the form of tethered acid groups, has been embedded within the polymer, and is liberated when polymer-solvent interface is formed. The resultant polymer-solvent system is driven to form interface, but is restricted by the elastic deformation of the polymer backbones. We present a general process for functionalizing convex energies and present a model of interfacial energy for the polymer electrolyte as the functionalization of the Allen-Cahn energy for surface area. The resulting model is fourth order, strongly nonlinear, but has considerable structure. While the functionalized energies inherit the critical points of the original energy, we show that a wide class of functionalized energies have minimizers which are distinct from those of the original energy. In particular functionalization generically destabilizes heteroclinic connections, while generating stable homoclinic and other pore type structures. We posit that functionalization is a fundamental mechanism for formation of the nanostructured interfaces essential for efficient energy conversion.

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MS55

Dissipative Solitons: Experiment versus Theory

We recall experimental results from electrical networks, gas-discharge devices, semiconductor components, chemical solutions and biological systems demonstrating that the emergence of Dissipative Solitons (DSs) is a universal phenomenon. DSs show up e.g. as stationary and travelling isolated pulses, and appear as elementary building blocks of stationary, travelling and rotating clusters, stationary, travelling and rotating hexagons, liquid- and gas-like states as well as patterns of higher complexity. Examples for currently observed interaction phenomena are reflection, scattering, formation of bound states, generation and annihilation. For a certain class of systems a normal form being given by a 3-component reaction-diffusion equation allows for a rather satisfying qualitative description of quite a number of experimentally observed phenomena. This class includes planar electrical transport devices. The relevance of the proposed normal form will be discussed in some detail. Finally we present some analytical and numerical results describing the solution behaviour of the 3-component reaction-diffusion equation. Thereby we will touch the following problems: The bifurcation of an isolated stationary DS, the interaction of DSs and the reduction of the field equation to a particle equation. The latter will be used to explore the behaviour of many-body DS systems. The work is supported by the Deutsche Forschungsgemeinschaft.

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MS55

Dynamics of Localised Patterns in Heterogeneous Media

Pulse wave is one of the main careers of information and the effect of heterogeneity of the media in which it propagates is of great importance for the understanding of signaling processes in biological and chemical tissues. To know the behaviors of pulse in a heterogeneous media is equivalent to study the collision process between the pulse and the defect. A remarkable thing is that PDE dynamics can be reduced to finite dimensional dynamics near a drift bifurcation and the defects become critical points of the reduced ODEs. A variety of outputs are observed depending on the height and width of the bump such as rebound, pinning, oscillatory motion as well as penetration. The basin of each critical point and the switching among those basins depending on parameters explain all the outputs after collision with the defects.

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MS55

Scattering Dynamics of Traveling Pulses Near Singularities

Scattering of traveling pulses is discussed. The output after collision of two pulses depends on parameters, however the underlying mechanism creating such varieties of outputs is not clearly visible if one look at only the dynamical behaviors of the pulse. It turns out that a saddle plays a crucial role to understand the scattering dynamics. A variety of scattering dynamics can be reduced to two things: one is the local dynamics of unfoldings of codim 2 singularities of single-hump type. The other is a heteroclinic connection from double-horn type unstable solution to single-hump one. This not only reflects on the global aspect of the scattering process, but global network structure among the ordered states is one of the keys to understand the complex dynamics.

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MS55

Front and Pulse Dynamics in a Three-component System

We study the dynamics of multi-front solutions of a specific three-component reaction-diffusion system. First, we consider the existence and stability of the stationary patterns – a 1-pulse or 2-front solution and a 2-pulse or 4-front solution – by singular perturbation and Evans functions techniques. Then, we use a renormalization group method to rigorously deduce the system of ODEs that govern the front dynamics. Based on our knowledge of the stationary points of this system, i.e., the stationary patterns, we are able to give an accurate description of the dynamics of N-front patterns (for N not too large).

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MS56

Optical Vortices in Photonic Lattices: Zener Tunnelling and Nonlinear

Optical orbital angular momentum can be transported by vortex light beams in free space while in periodic media, such as photonic lattices, it is not conserved during propagation. We discuss topological transformations of vortices undergoing Zener tunnelling in biased photonic lattices as well as multi-vortex clustering and localization in nonlinear regime with generation of stable discrete vortex solitons.

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MS56

Nonlinear Plasmonic Waveguides and Nanocavities

Abstract not available at time of publication.

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MS56

Spatio-temporal Effects in Nonlinear Fiber Arrays

Recently nonlinear waveguide arrays became a prominent system for the experimental study of fundamental effects of nonlinear dynamics, as, e.g. discrete soliton formation, spatio-temporal dynamics, the interplay between nonlinearity and disorder, as well peculiarities of wave propagation in periodic media. In two-dimensional arrays of silica fibers we study the propagation of spatio-temporal Kerr-solitons, so-called light-bullets. This class of solutions of the nonlinear Schrdinger equation undergoes collapse in bulk media. It can be stabilized by the discreteness along the transverse dimensions, leading to robust non-dispersive and non-diffractive packets of light being confined in all dimensions only by nonlinear self-focusing.

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MS56

Solitons and New Light-trapping Mechanism in Photonic Crystal Fibers and Nano-wires

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MS58

Coherent States and the Transition to Turbulence

The transition to turbulence in pipe flow is a longstanding problem in fluid dynamics. In contrast to many other transitions it is not connected with linear instabilities of the laminar profile and hence follows a different route. Experimental and numerical studies within the last few years have revealed many unexpected connections to the nonlinear dynamics of strange saddles and have considerably improved our understanding of this transition. I will summarizes some of these insights and points to some outstanding problems in areas which connect to coherent structures.

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MS58

Pipe Flow Dynamics on the Critical Threshold

A new family of finite amplitude travelling wave solutions in pipe flow has been identified and continued for a wide range of Reynolds numbers and pipe lengths. The implication of the aforementioned solutions in the transition process is studied by using the notion of a threshold separating initial conditions that lead to transition from others that end up relaminarizing. Using an accurate shooting method, trajectories on the edge between turbulence and laminarity are studied.

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MS58

Edge States for Pipe Flow

In pipe flow and some other shear flows the laminar profile is linearly stable and turbulence may only be achieved through finite amplitude perturbations. Regions of laminar and turbulent dynamics in the state space of the system are separated by the *edge of chaos*. Using an iterated bracketing technique we can numerically trace the dynamics in this edge of chaos and determine the invariant relative attractors. We will show results for plane Couette flow, pipe flow in the full space and in a symmetry reduced subspace to illustrate the variety of relative invariant attractors that can occur. The significance of these states lies in their governing role for triggering turbulence as well as for relaminarization.

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MS58

Coherent Structures in Localised and Global Turbulence

As pipe flow exhibits no known linear instability, there is no clear progression to increasingly complicated flows as the flow rate is increased. Only recently were exact nonlinear solutions discovered. Although these all appear to be unstable, tentative evidence is appearing to suggest that they are involved in turbulence. We find evidence of these nonlinear wave solutions in localised turbulent structures called 'puffs'. Their location is consistent with the belief that the known exact solutions are on the 'edge' of the laminar turbulent boundary. Evidence of waves at higher flow rates suggests new branches of more highly nonlinear solutions.

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MS59

Exponential Times in the Gross-Pitaevskii Equation with Multiple Well Potential

We consider the Gross-Petaevskii equation with a N-well trapping potential. We prove, in the semiclassical limit, that the finite dimensional eigenspace associated to the lowest N eigenvalues of the linear operator is slightly deformed by the nonlinear term into an almost invariant manifold M. Precisely, one has that solutions starting on M, or close to it, will remain close to M for times exponentially long with the inverse of the size of the nonlinearity. As heuristically expected the effective equation on M is a perturbation of a discrete nonlinear Schrodinger equation. We deduce that when the size of the nonlinearity is large enough then tunneling among the wells essentially disappears: that is for almost all solutions starting close to M their restriction to each of the wells has norm approximatively constant over the considered time scale. The proof is based on canonical perturbation theory; surprisingly enough, due to the Gauge invariance of the system, no non-resonance condition is required.

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MS59

Busse Ballons and the Bifurcations of Spatially Periodic Patterns

For a given PDE, a Busse balloon is a region in (wave nuber, parameter(s))-space in which stable, spatially periodic, wave trains exist. At the boundary of a Busse balloon, the spatially periodic patterns destabilize, and thus bifurcate. This boundary may have corners at codimension 2 bifurcations. The onset of pattern formation as described by weakly nonlinear stability theory and the Ginzburg-Landau equation describes only a small, but well-studied, part of a Busse balloon. In this talk we consider some global aspects of the boundary of Busse balloons in reaction-diffusion equations.

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MS59

Nonlinear Schrodinger Equations in the Semiclassical Limit

We consider a class of Schrodinger equations with a symmetric double-well potential and a nonlinear (”local” and ”nonlocal”) perturbation. We show that, under certain conditions, the reduction of the time-dependent equation to a two-mode equation gives the dominant term of the solution with a precise estimate of the error. More precisely, in the semiclassical limit we show that the finite dimensional eigenspace associated to the lowest eigenvalues of the linear operator is almost invariant for times of the order of the beating period and the dominant term of the wavefunction is given by means of the solutions of a finite dimensional dynamical system. This review is based on joint papers with D. Bambusi, V. Grecchi and A. Martinez.

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MS59

Asymptotic Analysis for Nonlinear Schrodinger Equations with Periodic Potentials

We review recent results on rigorous asymptotic studies of nonlinear Schrdinger equations with rapidly oscillating periodic potentials. These models naturally appear in the description of so-called lattice Bose-Einstein condensates. We will also show recent numerical simulations of such problems, using a newly developed Bloch-decomposition based pseudo-spectral method.

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MS60

Zakharov-Shabat Eigenvalue Problem with Random Potential

We consider a class of random initial value problems for a nonlinear channel modelled by the integrable Nonlinear Schrdinger equation (NLSE). Mathematically this problem translates into the non self-adjoint Zakharov-Shabat scattering problem (ZSSP) where the random input profile serves as a potential. Three different types of the random inputs are considered: i) complex symmetric Gaussian delta-correlated potential with a finite support; ii) real dichotomic process with finite correlation radius; iii) randomly modulated rectangular return-to-zero shape.

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MS60

Pulsating Dissipative Solitons

In nonlinear dissipative systems, stationary soliton solutions generally benefit from a high degree of stability. Pulsating solitons, which correspond to the existence of limit cycles, can also be found profusely. Using mainly the complex cubic-quintic Ginzburg-Landau equation as a model for optical systems, the following pulsations will be presented: vibrating or shaking soliton pairs in the $(1+1)D$ temporal case, and pulsating light bullets in the $(3+1)D$ spatio-temporal case, with numerical or collective variable approaches.

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MS60

Patterns in Periodically Modulated Parametric Amplifiers and Oscillators: Stability and Dynamics

We consider spatially localized and periodic field patterns in periodically modulated optical parametric amplifiers and oscillators. In the degenerate case (equal signal and idler beams) we elaborate the systematic method of construction of the stationary localized modes in the amplifiers, study their properties and stability. We describe a method of constructing periodic solutions in optical parametric oscillators and the dynamics of the instabilities of various patterns.

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MS60

Manipulation of Light Pulses with Light in Two-level Media

A two-level medium coupled to an electromagnetic radiation is described by the Maxwell-Bloch (MB) system. The medium can thus be engraved by establishing a standing cavity wave for a linearly polarized electromagnetic field that drives the medium on both ends. Then, a light pulse can be fire into the medium (for instance in the second polarization direction) to scatter the induced grating through (nonlinear) coupling to the population inversion density. We show that the freedom in the applied amplitudes of the grating field allows to stop the light pulse, to make it move backward, then forward, and so on. The process is understood by a discrete nonlinear Schroedinger equation with variable coupling coefficients, which reproduces the dynamics of the driven light pulse.

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MS62

Weighted Porous Medium Equation and Asymptotic Convergence to the Equilibrium

Using measure-capacity inequalities we study new functional inequalities, namely L^q-Poincaré inequalities and L^q-logarithmic Sobolev inequalities. As a consequence, we establish the asymptotic behavior of the solutions to the so-called weighted porous media equation

$$\frac{\partial u}{\partial t} = \Delta u^m - \nabla\psi \cdot \nabla u^m$$

for $m \geq 1$, in terms of L^2-norms and entropies.

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MS62

The Wasserstein Gradient Flow of Energies

Just as the Wasserstein gradient flow of entropy functionals generates second order diffusion equations, the gradient flow of the energies $E = \int |\nabla u^p|^2 dx$ generates parabolic PDEs of fourth order which generalize the Thin Film ($p = 1$) and DLSS ($p = 1/2$) equations. We sketch the proof for existence of solutions and estimate the rate of convergence to the steady state in the case of quadratic confinement potential.

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MS62

Optimal Transport for the System of Isentropic Euler Equations

We propose a variational time discretization for the multi-dimensional isentropic Euler equations. The approximation is inspired by the theory of abstract gradient flows on the space of probability measures and by Dafermos' entropy rate criterion: The total energy should be decreased at maximal rate. (Joint work with Wilfrid Gangbo and Jon Wilkening).

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MS63

Multipulse Solutions for Nonlinear Wave Equations

We investigate multipulse solutions consisting of N trains of M equidistant pulses travelling at the same velocity in the setting of a nonlinear wave equation. By an extended perturbation approach, which separates internal and interaction dynamics, we show that in leading order the only interaction effects are phase and envelope shifts. Hence, there is almost no interaction at all. This result leads to improved estimates for wavelength–division multiplexing techniques in optical communication lines.

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MS63

Existence and Stability of Global in Time Counterpropagating Two-Soliton Solutions in the FPU Lattice

We study the Fermi Pasta Ulam (FPU) lattice in the long wavelength, low amplitude KdV regime, where it may be regarded as a near-integrable system. Using recent work of Friesecke and Pego, Mizumachi, Martel, and Martel and Merle, we construct global in time solutions which are close to the sum of counterpropagating solitary waves at both $t = \infty$ and $t = -\infty$ and which pass through each other for intermediate values of t.

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MS63

Generalized Helmholtz-Kirchhoff Model for Two Dimensional Distributed Vortex Motion

The two-dimensional Navier-Stokes equations are rewritten as a system of coupled nonlinear ordinary differential equations. These equations describe the evolution of the moments of an expansion of the vorticity with respect to Hermite functions. We discuss the convergence of this expansion and show that in the zero viscosity and zero core size limit we formally recover the Helmholtz-Kirchhoff model for the evolution of point-vortices. The present expansion systematically incorporates the effects of both viscosity and finite vortex core size. We also show that a low-order truncation of our expansion leads to the representation of the flow as a system of interacting Gaussian i.e. Oseen) vortices which previous experimental work has shown to be an accurate approximation to many important physical flows [6].

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MS63

The Shooting Manifold for Reaction-Diffusion Equations in d Dimensional Space

Many reaction diffusion systems admit spatially localized traveling wave solutions which are dynamically stable under small perturbations. We show that this implies the existence of solutions which are roughly the linear superposition of many of these pulses, provided they are well-separated and are moving in different directions. These solutions are also dynamically stable. The main complication in establishing such results is due to the fact that one cannot simplify the problem by working in a co-moving reference frame. As a result, one has to invert a non-autonomous linear operator which is not a small perturbation of a time-independent one. Nevertheless this operator has certain special properties which allow us to treat it as if it were small. Certain of the solutions we construct represent a number of pulses "shooting" in towards one another from spatial infinity. All together, our results imply that the collision of several pulses is a well-defined scattering problem. By this we mean that investigations into the nature of the strong interactions which take place during the collision will not be affected by specific choices for the initial data which lead to this collision.

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MS64

Solitons and Semiconductor Microlasers

Creation and manipulation of microlasers which can be switched on and off by external optical control beams are demonstrated using a semiconductor microcavity (VCSEL) with frequency-selective feedback. These microlasers are interpreted as laser cavity solitons and are stabilized by nonlinearities. Frequency selection, polarization properties and dynamics of these structures are analyzed and approaches to modeling are discussed.

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MS64

Modelling of Quantum Dot Microcavities

We present an overview of the modelisation and study of the spatio-temporal dynamics of the coherent field emitted by a semiconductor microcavity based on self-assembled Quantum Dots. The pattern scenario is described and experimentally achievable conditions are predicted for the occurrence of stable cavity solitons.

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MS64

Switching with Coupled Photonic Crystal Cavities

Integrated photonic structures, such as photonic crystal cavities and ring resonators, have proven to be effective nonlinear devices. Here, we review the novel possibilities when multiple cavities are coupled to each other. Their strong and highly tunable feedback properties lead to effects such as switching with very low powers and symmetry breaking bifurcations. These phenomena are useful for all-optical flip-flop devices. The compact nanophotonic structures are efficiently analyzed with coupled-mode theory and rigorous numerical methods.

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MS64

Bose Einstein Condensation of Cavity Polaritons

The exciton-polaritons are two-dimensional quasiparticles of Fabry-Perot-type microcavities with embedded quantum wells, which result from the coupling between excitons (electron and hole pairs bound by Coulomb interaction) in the quantum wells and photon modes of the microcavity. Optical confinement in microcavities helps to achieve the strong coupling regime, when a characteristic anticrossing of the exciton and photon bands takes place, and two exciton-polariton dispersion branches are formed [A. Kavokin, G. Malpuech, Cavity Polaritons, Elsevier, Amsterdam (2003).]. Having extremely light effective masses, the polaritons may condense at the bottom of their lower dispersion branch if they thermalize quickly enough. Bose-condensation is a rare and intriguing physical phenomenon observed at ultra-low temperatures in superconductors, superfluids and atomic gases. Recently, and after about 10 years of efforts, the Bose condensation of cavity polaritons has been reported both at low [J. Kasprzak et al., Phys. Rev. B, 72, 201301, (2005); J. Kasprzak et al., Nature 443, 409, (2006); R. Balilli et al., Science, 316, 1007, (2007); C.W. Lai et al., Nature 450,529, (2007] and room temperature [S. Christopoulos et al. 98, 126405, Phys. Rev. Lett. (2007).]. In this presentation we will present the experimental and the theoretical activities and achievements of this research field as well as the main research directions for the future.

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MS65

Pulsating Fronts in Discontinuous Heterogeneous Media

Abstract not available at time of publication.

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MS65

Modeling of Multi-Step Reactions

We present a derivation of a basic model for multistep reactions with branching. Various assumptions are highlighted and we review results of Gasser & Szmolyan on existence and convergence of traveling profiles for such models.

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MS65

Stability of Fronts

We will discuss orbital stability of a PDE that appears in a combustion problem. This is a joint project with Anna Ghazaryan and Steve Schecter.

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MS66

Stability Characteristics of Highly Nonlinear Internal Solitary Waves

The stability characteristics of an internal solitary wave of depression in a shallow, two or three-layer fluid are investigated experimentally and theoretically. The initial background stratification is varied and it is found that the onset, type and intensity of breaking are dramatically effected by change in the background stratification. The two-layered stratification consists of a homogeneous dense layer below a linearly stratified top layer. In this regime a combination of shear and convective instability is seen on the leading face of the wave. It is shown that there is interplay between the two instability types and convective instability induces shear by enhancing isopycnal compression. In the three-layered regime a linearly-stratified pycnocline separates two homogeneous layers. In this regime, shear instability is seen at the trough of the wave and develops throughout the tail. Experimental results are compared with fully nonlinear theory. Excellent agreement is found in stable cases. In the unstable observations discrepancies between experiment and theory are used to explain the physics observed. Estimates of the wave properties (from experiment and theory) and evaluation of the Richardson number reveal significant new findings.

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MS66

Hamiltonian Long Wave Models for Internal Waves

We derive a Hamiltonian formulation of the problem of a dynamic free interface (with rigid lid upper boundary conditions), and of a free interface coupled with a free surface, this latter situation occurring more commonly in experi-

ment and in nature. Based on the linearized equations, we highlight the discrepancies between the cases of rigid lid and free surface upper boundary conditions, which in some circumstances can be significant. We also derive systems of nonlinear dispersive long wave equations in the large amplitude regime, and compute solitary wave solutions of these equations. This is joint work with W. Craig (McMaster University) and H. Kalisch (University of Bergen).

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MS66

Long Wave Model for Interfacial Waves and Application to the Interaction Between Interfacial Solitary Waves

Two different models for interfacial waves are derived by using two separate methods: a perturbation method and an asymptotic expansion method. One of these two models is shown to be more general, and is therefore used for the numerical simulations. The propagation and the collision between two solitary waves are studied in all cases, including the case where the density ratio is close to the depth ratio. Quantitative results for the run-up and the phase shift generated by these collisions are obtained with the help of iterative filtering.

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MS66

Numerical Modeling of Shoaling of Internal Solitons with Respect to Maximum Velocities

Measurements at the shelf slope outside mid Norway have showed sudden strong near seabed velocities. The high velocities are often connected to drop in temperature, similar to shoaling of solitons. The temperature drops indicate vertical pycnocline movements maybe up to 100 m. 2D non-hydrostatic numerical simulations of internal solitons shoaling along linear slopes were performed for different slopes and wave amplitudes where the maximum velocities generated during soliton breaking is studied.

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MS67

Nonlinear Dynamics of a System of Particle-like Wavepackets

We study nonlinear systems of hyperbolic PDE's with constant coefficients, the hyperbolicity is understood in a wider sense, namely multiple roots of the characteristic equation are allowed and dispersive equations are permitted. They describe wave propagation in dispersive nonlinear media such as, for example, electromagnetic waves in nonlinear photonic crystals. The methods are also applicable to lattice systems, such as Fermi-Pasta-Ulam system. This talk concerns the nonlinear evolution of a special class of wavepackets, namely particle-like wavepackets. A particle-like wavepacket on one hand has a well defined principal wave vector, on the other hand, it can be assigned a well defined position in the space. We prove that under the nonlinear evolution a generic multi-particle wavepacket remains to be a multi-particle wavepacket with a high accuracy, and every constituting single particle-like wavepacket not only preserves its principal wave number but also it has a well-defined space position evolving with a constant velocity which is its group velocity. Remarkably the described properties hold though the involved single particle-like wavepackets undergo nonlinear interactions and multiple collisions in the space. We prove that if principal wavevectors of multi-particle wavepacket are generic, the result of nonlinear interactions between different wavepackets is small and the approximate linear superposition principle holds uniformly with respect to the initial spatial positions of wavepackets. We also prove that the evolution of a multi-wavepacket is described with high accuracy by a properly constructed system of envelope equations with a universal nonlinearity. The universal nonlinearity is obtained by a time averaging applied to the original nonlinearity, in simpler cases the averaged system turns into a system of Nonlinear Schrodinger equations.

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MS67

Breather Solutions in Weakly Non-linear Dispersive Media

We consider a non-linear Klein-Gordon equation with periodic coefficients and show that under a special choice of coefficients a so-called breather solution exists, i.e. a solution to the equation

$$\partial_x^2 u = s(x)\partial_t^2 u + (q_0 + \varepsilon)u - u^3, \quad u, x, t \in R, \varepsilon << 1$$

with $u(x, t + \frac{2\pi}{\omega}) = u(x,t)$ and $u(x,t) \to 0$ as $|x| \to \infty$. Periodic PDEs have a band-structure with band-gaps. If all multiples of the frequency $n\omega$ fall into such a band-gap, the real part of all Floquet-exponents except of two are of order 1, whereas the two critical Floquet-exponents are of order ε. This allows a center-manifold reduction for which the reduced system has a homoclinic solution. This problem arises in the study of photonic crystals, artificially produced materials with lattice constant $\approx$ wavelength of visible light. They are strongly dispersive media which allow the use of the techniques discussed in this talk to show that there are standing pulses under certain circumstances. Eventually, this can be used for the design of optical buffers in slow-light systems.

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MS67

Wavepacket Propagation in Nonlinear Dispersive Media

We study nonlinear dispersive wave systems as described by hyperbolic PDE's, which include, in particular, electromagnetic waves in nonlinear photonic crystals. The initial data is assumed to be a finite sum of wavepackets referred to as a multi-wavepacket. The wavepackets and the medium nonlinearity are characterized by two principal small parameters: one is the ratio of the slow and the fast time scales, and another one is the ratio of the small and the large space scales. A key element in our approach is a proper definition of a wavepacket. Remarkably, the introduced definition has sufficient flexibility for a wavepacket to preserve its defining properties under a general nonlinear evolution for long times. In particular, the corresponding wave vectors and the band numbers of involved wavepackets are "conserved quantities". We prove that the evolution of a multi-wavepacket is described with high accuracy by a properly constructed system of envelope equations with a universal nonlinearity, obtained by a time averaging applied to the original nonlinearity, in simpler cases the averaged system turns into a system of Nonlinear Schrodinger equations. We also show that a wide class of such systems, including nonlinear Schrodinger and Maxwell equations, Fermi-Pasta-Ulam model and many other not completely integrable systems, satisfy a superposition and wavepacket preservation principles. The superposition principle essentially states that if a wave starts initially as a sum of generic wavepackets then with a high accuracy it will remain to be a sum of wavepackets evolving nonlinearly and independently from each other.

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MS67

Justification of the Tight-binding Approximation

We justify the validity of the discrete nonlinear Schrödinger equation for the tight-binding approximation in the context of the Gross–Pitaevskii equation with a periodic potential. We rely on properties of the Floquet band-gap spectrum and the Fourier–Bloch decomposition for a linear Schrödinger operator with a periodic potential. Our analysis is valid for a class of piecewise-constant periodic potentials with disjoint spectral bands, which reduce, in a singular limit, to a periodic sequence of infinite walls of a finite width. The discrete nonlinear Schrödinger equation is applied to classify localized solutions of the Gross–Pitaevskii equation with a periodic potential. Time evolution of localized solutions is studied on large but finite time intervals using analysis involving energy estimates and Gronwall's inequality.

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MS68

Analytic Results in the Four-wave Mixing Model of Dynamic Holography

The nonlinear interaction of four monochromatic waves can create holograms in photorefractive crystals. In this system of five complex equations in five complex amplitudes (four-wave mixing), we determine the conditions for nonchaotic solutions to exist. When the response is nonlocal, explicit time-dependent solutions can be obtained in terms of elliptic functions, i.e. including the physically relevant pulses.

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MS68

Commutator Identities on Associative Algebras and Integrability of Nonlinear pde's

Commutator identities on associative algebras generate operator solutions of linearized versions of the integrable equations. A special class of integral operators realizing representation of associative algebras is introduced and generic conditions defining such representation are formulated. A special dressing procedure is introduced that enables derivation of the nonlinear integrable equations and their Lax pairs for given linearized versions. Thus, problem of construction of new integrable equations and their classification is reduced to a problem of construction of commutator identities on associative algebras.

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MS68

Inverse Scattering Transform for the Vector NLS Equation with Non-vanishing Boundary Conditions

The inverse scattering transform for the vector defocusing vector nonlinear Schrodinger (NLS) equation with non-vanishing boundary values at infinity is constructed. The direct scattering problem is formulated on a two-sheeted covering of the complex plane. On the direct side, two out of the six scattering eigenfunctions do not admit an analytic extension on either sheet of the surface. Two additional analytic solutions are constructed by considering "adjoint" eigenfunctions. The discrete spectrum, bound states and symmetries of the direct problem are discussed. In general a discrete eigenvalue corresponds to a quartet of zeros (poles) of certain scattering data. The inverse scattering problem is formulated in terms of a Riemann-Hilbert (RH) problem in the upper/lower half planes of a suitable uniformization variable. Special soliton solutions, which have dark solitonic behavior in both components and ones which have one dark and one bright component are constructed from the poles in the RH problem. The linear limit is obtained from the RH problem and is shown to correspond to the Fourier solution obtained from the linearized vector NLS system.

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MS68

Dark Solitons in Nonlinear Schroedinger Systems

Unlike the standard “bright” solitons, dark solitons are localized regions of low intensity on a spatially and temporally nonvanishing background. Dark solitons, including those in nonlinear Schrödinger (NLS) systems, have received comparatively little attention as compared to the extensive literature on bright solitons. In fact, in vector NLS the dark and bright solitons can be considered as limiting cases of a dark-bright structure. We will give a progress report on investigation of the dynamics and structure of dark and dark-bright solitons, primarily from the point of view of the inverse scattering transform.

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MS70

Critical Mass for a Patlak-Keller-Segel Model with Degenerate Diffusion in Higher Dimensions

This talk is devoted to the analysis of non-negative solutions for a generalisation of the classical parabolic-elliptic Patlak-Keller-Segel system with d greater or equal to 3 and porous medium-like non-linear diffusion. Here, the non-linear diffusion is chosen in such a way that its scaling and the one of the Poisson term coincide. We exhibit that the qualitative behaviour of solutions is decided by the initial mass of the system. Actually, there is a sharp critical mass M_c such that if $M \in (0, M_c]$ solutions exist globally in time, whereas there are blowing-up solutions otherwise. We also show the existence of self-similar solutions for M in $(0, M_c)$. While characterising the eventual infinite time blowing-up profile for $M = M_c$, we observe that the long time asymptotics are much more complicated than in the classical Patlak-Keller-Segel system in dimension two.

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MS70

Weak Solutions with Large Data to a System in Quantum Fluid Dynamics

We consider the global existence of weak solutions to a class of Quantum Hydrodynamics (QHD) systems with initial data, arbitrarily large in the energy norm. These type of models, initially proposed by Madelung, have been extensively used in Physics to investigate Supefluidity and Superconductivity phenomena and more recently in the modeling of semiconductor devices . Our approach is based on various tools, namely the wave functions polar decomposition, the construction of approximate solution via a fractional steps method, which iterates a Schrödinger Madelung picture with a suitable wave function updating mechanism. Therefore several *a priori* bounds of energy, dispersive and local smoothing type allow us to prove the compactness of the approximating sequences. No uniqueness result is provided.

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MS70

Kato Smoothing Effect for the Water Wave Problem with Surface Tension

Abstract not available at time of publication.

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MS70

Higher Derivative Estimates for the Navier-Stokes Equation

In this talk, we show how the third derivatives of solutions to the 3D Navier-Stokes equations can be bound in L^1 weak. The proof uses blow-up techniques and relies on a non linear scaling of the dissipation of energy. Estimates can be obtained by this means thanks to the galilean invariance of the transport part of the equation.

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