IP1

Pressure Transients and Fluctuations in Natural Gas Networks caused by Gas-Electric Coupling

Natural gas-fired generators are often used to balance the fluctuating output of wind generation within electric power transmission systems. However, the time-varying output of these generators results in time-varying natural gas burn rates that impact the pressure in interstate transmission pipelines. Fluctuating pressure impacts the reliability of natural gas deliveries to those same generators and the safety of pipeline operations. Motivated by this new emerging significance of the gas-grid coupling I start the talk reviewing gas-dynamic models of natural gas pipelines and describe how to utilize this modeling to explore the effects of intermittent wind generation on the fluctuations of pressure and transients in natural gas pipelines. I will also discuss significance, use and pecularities of the gas-dynamics modelings and simulations in gas-grid stochastic optimization and control problems.

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IP2

Invariant and Quasi-invariant Measures for Hamiltonian PDEs

In this talk, we discuss probabilistic aspects in the study of dispersive Hamiltonian PDEs such as the nonlinear Schrödinger equations. Lebowitz-Rose-Speer '88, Bourgain '94, and McKean '95 initiated the study of invariant Gibbs measures for dispersive Hamiltonian PDEs. In the first part of the talk, we give a review on the construction of invariant Gibbs measures and discuss how it lead to a recent development of probabilistic construction of solutions in late 2000s. In the second part of the talk, we consider the transport property of Gaussian measures. In particular, we show quasi-invariance of Gaussian measures on Sobolev spaces under certain dispersive Hamiltonian PDEs. We also discuss the importance of dispersion in this quasi-invariance result by showing that the transported measure and the original Gaussian measure are mutually singular when we turn off dispersion. The second part of the talk is based on a joint work with Nikolay Tzvetkov (Université Cergy-Pontoise) and Philippe Sosoe (Harvard University).

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IP3

Fluid Dynamics at Zero Reynolds Number: Nonlinearities in a Linear World

When describing some biological flows, small length and time scales allow inertia to be neglected in mathematical models, and the fluid dynamics may be described by the linear Stokes equations. However, when the flow is coupled to passive or actuated elastic structures, nonlinear behavior can occur. We will discuss some examples of these complex systems in the context of cilia, flagella and viscoelastic networks at the microscale.

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IP4

Fascinating Nonlinear Interactions in Metamaterials

Metamaterials, or artificial materials with unusual wave responses, have recently received significant attention in the context of non-linear optics, since they allow a dramatic boosting of light-matter interactions, and a corresponding enhancement of non-linear processes. In my talk, I will overview our recent research activity in the area of nonlinear metamaterials and their applications, including the possibility of controlling with nanoscale resolution the phase and amplitude of largely enhanced nonlinear processes over a metasurface, the unusual nonlinear dynamics of topological metamaterials, and optimal bounds on time-reversal symmetry breaking induced by nonlinear processes. Our results open exciting directions in nonlinear physics, and in the talk I will discuss the mathematical relevance of these problems and their impact on future technology.

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IP5

Nonlinear, Nondispersive Surface Waves

Surface waves are waves that propagate along a boundary or interface and decay exponentially away from it. Deep water waves are familiar examples of dispersive surface waves, but this talk will focus on nondispersive surface waves. Physical examples include Rayleigh waves on an elastic half-space, surface waves on a vorticity discontinuity, which can be modeled by a Burgers-Hilbert equation, and high-wavenumber surface plasmons on an interface between a dielectric and a conductor. An asymptotic analysis of weakly nonlinear, nondispersive surface waves leads to spatially nonlocal equations that describe the nonlinear mixing of the spectral components of the wave. Typically, these equations have short-time well-posedness for smooth solutions, but numerical simulations show the formation of singularities in finite time. Proofs of singularity formation and the existence of global weak solutions for these nonlocal equations often appear to be difficult and many open questions remain.

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IP6

Shaping Quantum Matter with Light: Exploiting Pattern Formation in Exciton-polariton Condensates

Our modern digital society is largely built on optoelectronic devices that manipulate separately the semiconductor charge carriers and the light. The goal of polaritonics the new emerging field of research is to replace fermions (holes, electrons) by bosons, such as exciton-polaritons for the new generation of optoelectronic devices. Bosonic stimulation of optical transition, high coherence, room-temperature condensation, high nonlinearity will pave the way to realization of devices characterized by high quantum efficiency, ultrashort switching time and very low signal losses. Exciton-polariton quasi-particle is a mixture of photon confined in a microcavity and exciton in an embedded semiconductor Recent experiments investigated exciton - polariton condensation and the phenomena associated with it, such as pattern formation, quantised vortices and solitons, increased coherence and the cross-over to regular lasing. I will discuss our understanding of pattern formation and dynamics in polariton condensates to date and suggest how to exploite polariton condensate dynamics in applications.

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IP7
Parity-Time Symmetry in Optics

Recently, the idea of judiciously incorporating both optical gain and loss was suggested as a means to control the flow of light. This proposition made use of some newly developed notions based on parity-time (PT) symmetry that were initially conceived within the framework of quantum-field theories. Since then, parity-time (PT) symmetry has emerged as a new powerful paradigm in optics. In this talk, we provide an overview of recent developments in this newly emerging field.

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IP8
The Role of Mathematics in Neuroscience

Mathematical and computational neuroscience have made great recent advances. I will illustrate how mathematics can provide deep insights into neuronal systems in the brain through new theoretical and computational approaches. I will discuss spatiotemporal dendritic information integration using PDE methods, a stochastic inverse problem of reconstructing neuronal network topology using Granger causality, compressive sensing principles embedded in early sensory pathways, and spatiotemporal dynamics of the primary visual cortex using large scale computational modeling. I will also discuss experimental verification and ramifications related to these results.

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SP1
Martin D. Kruskal Prize Lecture - A Dynamicists View of Stability in Multi-Dimensions

There are many ways to approach the stability analysis of a wave, steady or traveling, in one space dimension. These largely rely on treating the spatial dimension as an evolutionary variable, and hence allow the use of dynamical systems techniques. The same perspective does not appear to help in higher dimensions except for domains with a one-dimensional character, such as channels, or by restricting to specific classes of functions, such as radial solutions. The question I will pose is the following: Can we conceive of a way to look at a multi-dimensional problem so that these powerful dynamical systems-based techniques can be used? I will approach this from two different directions. First, by asking if we can recast the one-dimensional problem so that its generalization to higher dimensions is natural: The Morse Index Theorem is particularly instructive here. Secondly, by looking carefully how we apply the methodology of the Evans Function in one space dimension and to what end. I will be describing a set of ideas that draw on the efforts of a number of people who have lent me their shoulders to stand on.

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CP1
Modulating Functions Method for Parameters Estimation of High Order Nonlinear Wave Equations

Inverse problems to estimate coefficients of high order nonlinear wave equations such as the fifth order KdV and the sixth order Boussinesq equations are considered. A method based on the modulating functions is proposed to solve these inverse problems. The main advantages of this approach are: it simplifies the identification problem to the solution of a system of linear algebraic equations; it does not require the initial values; and it is robust against corrupting noises.

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CP1
Hydrogen Bonds and Nonlinear Waves in DNA Dynamics

We study a type of generalized saturable nonlinear Schrodinger equation, derived for the quasi-spin model of DNA, subjected to the action of a protein and a bath of phonons by using the Generalized Coherent State approach (Takeno-Homma model), applied for averaging the cuasi-spin Hamiltonian for DNA macromolecule. We analize some special cases (analytically and numerically): 1) when the external interaction disappears from the equation, and 2) of weakly saturating approximation.

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CP1
Random Attractor for Stochastic Lattice Reversible Gray-Scott System with Additive Noise

We prove the existence of a random attractor of the stochastic three-component reversible Gray-Scott system on infinite lattice with additive noise. We use a transformation of addition involved with O-U process, for proving the pullback absorbing property and the pullback asymptotic compactness of the reaction diffusion system with cubic nonlinearity.

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CP1

Dynamic Importance Sampling for Errors in An Actively Mode-Locked Laser Model

We consider a soliton-based, actively mode-locked laser model with a very low probability of pulses slipping relative to the mode-locking. We study the probability of these error modes occurring using dynamic importance sampling. For this problem deviations between an initially determined optimal path and an actual trajectory can become large, and dynamic importance sampling corrects for this.

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CP2

Stable Normalized Solitary Waves for Nonlinear Schrodinger Systems

This talk is concerned with the existence of stable solitary waves for coupled nonlinear Schrodinger systems, studied via their variational characterizations. The method is based on the fact that solitary waves are critical points of the Hamiltonian for fixed values of the conserved quantities which arise from the symmetries. A standard way to prove existence of minimizers is to rule out loss of compactness of minimizing sequences by establishing the subadditivity of the minimum Hamiltonian with respect to constraint variables. For variational problems with only one constraint or when two constraints are not independently chosen, this has been done using several techniques, but for problems with multiple independent constraints, even for the most universal choice of coupling terms, proving subadditivity has been difficult in the past. Here we establish the subadditivity condition under multiple mass constraints and thus obtaining existence and stability of disjoint sets of coupled normalized solitary waves.

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CP2

New Types of Multi-Soliton Solutions of the Higher Order KdV Equations

Some effects in the soliton dynamics governed by the higher order KdV-type equations are discussed based on the exact explicit solutions derived by applying a direct method for constructing solitary wave solutions of evolution equations (G.I. Burde, J. Phys. A **43**, 085208 (2010); G.I. Burde, Phys. Rev. E **84**, 026615 (2011)). The results are extended to multi-soliton solutions using modifications of Hirota's method. The 'generalized Kaup–Kupershmidt' (GKK) solitons, which unify the structures of the KdV-like soliton and the Kaup–Kupershmidt soliton, and the steady-state localized structures, which behave like static solitons upon collisions with regular moving solitons, are considered.

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CP2

On the Degenerate Soliton Solutions of the Focusing Nonlinear Schrodinger Equation

We characterize N-soliton solutions of the focusing nonlinear Schrodinger (NLS) equation with degenerate velocities, i.e., solutions in which two or more soliton velocities are the same. First we analyze soliton solutions with fully degenerate velocities (a so-called multi-soliton group). We then consider the dynamics of soliton groups interaction in a general N-soliton solution; we compute the long-time asymptotics and quantify the interaction-induced position and phase shifts, as well as the interaction-dependent shape changes of each soliton group.

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CP2

Topological Structures of the Exact Solution for N Internal Waves in Three Dimensions

Topological properties of the exact solution of the Navier-Stokes system of PDEs for N internal waves are discussed. The periodic Dirichlet problems are formulated for conservative internal waves vanishing at infinity in upper and lower domains and solved through the kinematic and dynamic Euler-Fourier structures using the method of decomposition in invariant structures implemented by the experimental and theoretical programming in Maple. Existence conditions for slanted, rectangular, and stepped wave lattices are obtained.

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CP2

Existence of Bound States for a $(N + 1)$-Coupled Long-Wave-Short-Wave System

We prove the existence of an infinite family of smooth positive bound states for $(N+1)$-coupled long-wave–short-wave

interaction equations using a variational technique based on the concentration compactness principle. The interaction system involves N nonlinear Schrödinger-type short waves and a Korteweg de Vries-type long wave and is of interest in physics and fluid dynamics.

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CP2

On Peakon and Solitary Wave Solutions to a New Type of Modified Fornberg-Whitham Equation

In this letter, we study a new type of the Modified Fornberg-Whitham equation founded by the authors in 2015. We derive the explicit peakon and solitary wave solutions to the following new nonlinear dispersive equation

$$u_{xxt}-\nu^2u_t+3u_x^3+9uu_xu_{xx}+\frac{3}{2}u^2u_{xxx}-\frac{3}{2}\nu^2u^2u_x-\nu^2u_x=0, \quad (1)$$

where ν is a constant, and explore the possible applications to water waves.

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CP3

A Numerical Algorithm for Two Dimensional Hyperbolic Type Partial Differential Equations

In this article, a numerical algorithm based on finite difference and differential quadrature method is developed for numerical simulation of two dimensional hyperbolic partial differential equations with initial and boundary conditions. In the development of the scheme, the first step is semi-discretization in time with finite difference and then obtained system is fully discretized by differential quadrature method. Finally, we obtain a Lyapunov system of linear equations which is solved by Matlab solver for the system.

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CP3

Shock Wave Solutions for a Burger's Type Equation in Fluids and Plasmas

In this work, shock wave solutions for nonlinear Burgers' type equation, which arises in fluid and plasmas, is studied through Lie Group approach. Using suitable similarity transformations, the given Burgers' type equation is reduced to ordinary differential equations (ODEs). During the procedure of reduction, sometime we got some highly nonlinear ODEs which are not easily solvable. Therefore, numerical methods are applied to the ODEs for constructing numerical solutions in form of shock waves.

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CP3

Breather Solutions for a Model Type FPU Using Birkhoff Normal Forms

We present results on spatially localized oscillations in some inhomogeneous nonlinear lattices of Fermi-Pasta-Ulam (FPU) type derived from phenomenological nonlinear elastic network models used in the study of protein vibrations. The main feature of the FPU lattices we study is that the number of interacting neighbors varies from site to site, and we see numerically that this spatial inhomogenity leads to spatially localized normal modes in the linearized problem. This property is seen in 1-D models, as well as a 3-D models obtained from protein data. The spectral analysis of these examples suggests some non-resonance assumptions that can be used to show the existence of invariant subspaces of spatially localized solutions in Birkhoff normal forms.

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CP3

Haar Wavelets Solutions for Equal Width Burgers Type Equations

In this work, Haar wavelet method is used to obtain the numerical solution for equal width Burgers type equations which arises in fluid and plasmas. The method is straightforward and concise, and its applications are promising. It is shown that Haar wavelet method, with the help of symbolic computation, provides a very effective and powerful mathematical tool for solving EW-Burgers equation

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CP3

Transition and Turbulence in a Wall-Bounded Channel Flow at High Mach Number

The turbulence in the viscous, compressible flow in a 3D wall-bounded channel, simulated using the direct simulation Monte Carlo (DSMC) method, has been used as a test bed for examining different aspects of transition and turbulence at high Mach $Ma = U_m/(\gamma k_B T_w/m)$, and Reynolds numbers $Re = (\rho_m U_m H)/_w$. Here, H is the channel half-width, U_m is the mean velocity, ρ_m is the mean density, T_w is the wall temperature, m is the molecular mass, μ_w is the molecular viscosity, and k_B is the Boltzmann constant. The laminar-turbulent transition is accompanied by a discontinuous change in the friction factor even at high Mach number. The transition Reynolds number increases faster than linearly with Mach number, and the Knudsen number at transition passes through a maximum as the Mach number is increased. This maximum value is small, less than 0.009, indicating that transition is a continuum phenomenon even at high Mach numbers. In a compressible turbulent channel flow we examine the result that the ratio of the mean free path and Kolmogorov scale increases proportional as ($Ma/Re^{1/4}$), and it increases asymptotically with Mach number in the high Mach number limit. The simulation show that this ratio does decrease as ($Re^{-1/4}$), but it does not increase linearly with Mach number. This is due to the decrease in the local Mach number within the channel, due to the increase in the temperature by viscous heating.

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CP4

Compressible Viscous Flows Over a Non-Convex Corner

In this talk I will talk about compressible viscous flows over a non-convex corner. The flows are separated by a streamline emanating from the non-convex corner: One is the streamline coming from the inflow boundary and the other one is a rotational flow under the streamline. This is analyzed based on the corner singularity theory, piecewise regularity of solutions for mixed type partial differential equations.

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CP4

Nonlinear Wavetrains in Viscous Conduits

Viscous fluid conduits provide an ideal system for the study of dissipationless, dispersive hydrodynamics. A dense, viscous fluid serves as the background medium through which a lighter, less viscous fluid buoyantly rises. If the interior fluid is continuously injected, a deformable pipe forms. The long wave interfacial dynamics are well-described by a dispersive nonlinear partial differential equation. In this talk, experiments, numerics, and asymptotics of the viscous fluid conduit system will be presented. Structures at multiple length scales are discussed, including solitons, dispersive shock waves, and periodic waves. Modulations of periodic waves will be explored in the weakly nonlinear regime with the Nonlinear Schrodinger (NLS) equation. Modulational instability (stability) is identified for sufficiently short (long) periodic waves due to a change in dispersion curvature. These asymptotic results are confirmed by numerical simulations of perturbed nonlinear periodic wave solutions. Also, numerically observed are envelope bright and dark solitons well approximated by NLS.

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CP4

Internal Gravity-Capillary Solitary Waves in Finite Depth

Internal waves are waves which propagate along the interface of two fluids of different density. In this talk I will present some new results regarding existence of internal solitary waves under the influence of gravity and surface tension. The main idea is to use a spatial dynamics approach and formulate the steady Euler equations as an evolution equation. This equation is then studied by using the center manifold theorem. These techniques have previously been applied succesfully to the surface wave case.

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CP4

Weakly Nonlinear Waves in Real Fluids

We study the propagation of weakly nonlinear waves in real fluids, where the fundamental derivative changes sign. A method of multiple scales is used to study the behavior of the flow governed by the Navier-Stokes equations, supplemented by a van der Waals EOS. Effects of van der Waals parameters upon the wave evolutions are investigated. To validate our analytical results, we provide a numerical treatment of the problem using WENO scheme.

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CP4

A Whitham-Boussinesq Long-Wave Model for Variable Topography.

We study the problem of wave propagation in a long-wave asymptotic regime over variable bottom of an ideal irrotational fluid. We use the framework of the Hamiltonian formulation of the problem in which the non-local Dirichlet-Neumann operator appears explicitly in the Hamiltonian. We propose a non-local Hamiltonian model for bidirectional wave propagation in shallow water that involves pseudo-differential operators that simplify the Dirichlet-Neumann operator for variable depth. These models generalize the Boussinesq system as they include the exact dispersion relation in the case of constant depth. We present results for the normal modes and eigenfrequencies of the linearized problem. We see that variable topography introduces effects such as steepening of normal modes with increasing variation of depth, as well as amplitude modulation of the normal modes in certain wavelength ranges. Numerical integration shows that the constant depth non-local Boussinesq model with quadratic nonlinearity can capture in good qualitative agreement the evolution obtained with higher order approximations of the Dirichlet-Neumann operator. In the case of variable depth we observe that wave-crests seem to have variable speed, they seem to travel faster out of the shallowest area. We also observe certain oscillations in width of the crest and also some interesting textures and details in the evolution of wave-crests during the passage over obstacles.

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CP4

On the Small Dispersion Limit of Certain Two-Dimensional PDEs

We present various analytical and numerical results about the Whitham modulation theory for the Kadomtsev-Petviashvili equation and the 2-dimensional Benjamin-Ono equation.

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CP4

Expansion of a Wedge of Non-Ideal Gas into Vacuum

We study the problem of expansion of a wedge of non-ideal gas into vacuum in a two-dimensional bounded domain. The non-ideal gas is characterized by a van der Waals type equation of state. The problem is modeled by standard Euler equations of compressible flow, which are simplified by a transformation to similarity variables and then to hodograph transformation to arrive at a second order quasilinear partial differential equation in phase space; this, using Riemann variants, can be expressed as a non-homogeneous linearly degenerate system provided that the flow is supersonic. For the solution of the governing system, we study the interaction of two-dimensional planar rarefaction waves, which is a two-dimensional Riemann problem with piecewise constant data in the self-similar plane. The real gas effects, which significantly influence the flow regions and boundaries and which do not show-up in the ideal gas model, are elucidated; this aspect of the problem has not been considered until now.

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CP5

Anomalous Diffusion of the Complex Ginzburg-Landau Equation

The complex Ginzburg-Landau equation exhibits coherent or incoherent spatiotemporal dynamics, which consist of local waves named dissipative solitons. We investigate fluctuations of the dissipative solitons and then show that anomalous diffusion of the dissipative solitons emerges in the dynamics. To catch the nature of the diffusive behaviors, we construct a stochastic differential equation for describing intermittency with long memory, and give analytical description of statistical properties of it.

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CP5

Small Data Scattering of Fractional Hartree Equations

In this talk we will consider scattering problem of the fractional Schrödinger equations with Hartree type potential $\mu|x|^{-\gamma}$. The non-existence of scattering for $0 < \gamma \leq 1$ and small data scattering for $2 < \gamma < d$ will be presented briefly. In order to get a good time decay it is useful to use vector field $\mathbf{J} = x + i\alpha|\nabla|^{\alpha-2}\nabla$, which enables us to show a smalls data cattering when $\frac{6-2\alpha}{4-\alpha} < \gamma < 2$. The main difficulty is caused by the non-locality and low dipserson of $|\nabla|^{\alpha}$. These will be settled down by commutator estimates via Balakrishnan's formula.

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MS1

Semiclassical Initial/Boundary Value Problems

The unified transform method is a variant of the inverse-scattering transform for mixed initial-boundary value problems for integrable PDE possessing Lax pairs. It is based on the use of both equations of the Lax pair to deduce spectral transforms of the initial and boundary data, and it leads to a Riemann-Hilbert problem whose solution encodes that of the initial-boundary value problem. The main difficulty with the method is that computation of the spectral transforms requires knowledge of more boundary conditions than are needed to make the problem well-posed. Rather than resort to the global relation satisfied by the spectral transforms of consistent boundary data, we propose an explicit approximation to the nonlinear Dirichlet-to-Neumann mapping for the defocusing nonlinear Schrödinger equation that is valid in the semiclassical limit and explicitly eliminate the unknown boundary values. We use this approximation to generate an approximate solution and study it near the initial time and near the boundary in the semiclassical limit. We prove the existence of a vacuum domain, an unbounded region of the (x, t)-plane in which the solution is small given homogeneous initial data. We analyze the solution in the vacuum domain using the $\overline{\partial}$ steepest descent method. This is joint work with Zhenyun Qin (Fudan University).

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MS1

Dispersive Quantization of Linear and Nonlinear Waves

The evolution, through spatially periodic linear dispersion, of rough initial data leads to surprising quantized structures at rational times, and fractal, non-differentiable profiles at irrational times. The Talbot effect, named after an optical experiment by one of the founders of photography, was first observed in optics and quantum mechanics, and

leads to intriguing connections with exponential sums arising in number theory. Ramifications of these phenomena and recent progress on the analysis, numerics, and extensions to nonlinear wave models will be discussed.

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MS1

Dispersive Quantization Using the Unified Transform Method

Boundary value problems have been shown to possess an interesting property known as dispersive quantization or the "Talbot effect." The evolution of piecewise constant initial data leads to quantized structures at rational times and fractal profiles at irrational times. The Unified Transform Method (UTM) is applied to gain a deeper understanding of this phenomenon.

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MS1

Corner Singularities, Gibbs Phenomenon and the Unified Transform Method

Consider solving a linear, constant-coefficient evolution PDE in one spatial dimension where the initial data vanishes on the negative half line ($x < 0$). One can interpret this solution, restricted to $x > 0,\ t > 0$, as the solution of an initial-boundary value problem where the boundary data is not compatible with the initial data. This solution exhibits a corner singularity. Furthermore, in a dispersive and non-dissipative setting such a solution typically exhibits Gibbs-like high-oscillation and non-vanishing overshoot as t tends to zero. In this talk, I will discuss the behavior of corner singularities and their relation to the classical Gibbs phenomenon. I will also discuss the computation of these singular solutions.

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MS2

Frequency Downshifting in a Viscous Fluid

Frequency downshift, i.e. a shift in the spectral peak to a lower frequency, in a train of nearly monochromatic gravity waves was first reported by Lake *et al.* (1977). Even though it is generally agreed upon that frequency downshifting (FD) is related to the Benjamin-Feir instability and many physical phenomena (including wave breaking and wind) have been proposed as mechanisms for FD, its precise cause remains an open question. Dias *et al.* (2008) added a viscous correction to the Euler equations and derived the dissipative NLS equation (DNLS). In this talk, we introduce a higher-order generalization of the DNLS equation, which we call the viscous Dysthe equation. We outline the derivation of this new equation and present many of its properties. We establish that it predicts FD in both the spectral mean and spectral peak senses. Finally, we demonstrate that predictions obtained from the viscous Dysthe equation accurately model data from experiments in which frequency downshift occurred.

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MS2

A Priori Symmetry and Decay Properties of a Nonlocal Shallow Water Wave Equation

We prove the following interesting connection: that traveling solitary waves of a nonlocal wave equation are necessarily symmetric, monotone on a half-line, and of exponential decay rate; and that symmetric solutions of the initial-value problem for the same equation are necessarily traveling. Whereas the second proof is based on a quite general structural property (which we extend here to a nonlocal setting), the proof of the first three facts relies on a detailed analysis of the Fourier transform of $m(\xi) = \sqrt{\frac{\tanh \xi}{\xi}}$, which we prove is completely monotone. More precisely, we study the Whitham equation

$$u_t + uu_x + \int K(x-y)u_x\,dx = 0,$$

where the integral kernel K has the symbol $m(\xi)$, arising naturally in the study of water waves. The talk is based on recent results joint with Gabriele Brüll and Long Pei; Anna Geyer; and Erik Wahlén.

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MS2

Experiments on Downshifting of Freely-Propagating Surface-Gravity Waves

We present laboratory experiments on the frequency downshift of freely propagating surface gravity waves. We use a narrow-banded spectrum as initial data and measure its subsequent evolution. We vary carrier wave frequency and amplitude, perturbation wave frequency and amplitude, a measure of the narrow-bandedness of the spectrum, and the condition (cleanliness) of the air-water interface. There are at least two definitions of downshifting in freely propagating waves: (i) the downshift of the spectral peak and (ii) the downshift of the average spectral frequency. We examine how these two definitions describe the observations, and compare observations and predictions of the downshift of the average spectral frequency from models available in the literature.

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MS2

Stability and Long Time Modulational Dynamics

of Periodic Waves in Dissipative Systems

The capability of spatially periodic waves to cary modulation signals makes their dynamics under perturbation rich in multi-scale phenomena and essentially infinite dimensional. Here, I will discuss recent progress in the understanding of the stability and local dynamics of periodic waves capable of carrying multiple modulation signals in dissipative models, and in particular how (locally) the long time dynamics are approximately governed by an averaged system of equations obtained through a nonlinear WKB process.

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MS3

An Analytical and Numerical Investigation of Rogue Wave Prototypes

The spatially periodic breather (SPB) solutions and rational solutions of the nonlinear Schrodinger equation have emerged as prototypes for rogue waves. Our analytical and numerical investigations of the stability of these two classes of solutions indicate only the "maximal' SPBs are robust with respect to general perturbations of the initial data. This stability study potentially provides a useful tool for identifying physically realizable wave forms in experimental and observational studies of rogue waves.

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MS3

Long Range Propagation of Thin Features Using Nonlinear Solitary Waves

A method for computing short wave equation pulses or thin vortex filaments, propagating over arbitrarily long distances is presented. It is based on the author's 2012 J.C.P. article.The method uses the same term added to the relevant pde for both waves and vortices. The modified pde is then discretized on a uniform Eulerian computational grid. The pde's form nonlinear solitary waves, and, when discretized, can numeriically propagate them over arbitrarily long distances, in spite of discretization error, even though they are captured mostly, over only 2-3 grid cells. With the Eulerian grid, other, smoothly varying, important dynamical features can automatically be treated, for realistic applications.

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MS3

Extreme and Nonlinear Propagation of Optical Filaments in Air

Light filamentation is an extreme nonlinear optical phenomenon that can be obtained under certain conditions during propagation of powerful laser pulses in nonlinear media. In this talk, I discuss the spatio-temporal events that occur during formation of filamentation in atmosphere.

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MS3

Spatiotemporal Wave Propagation in Multimode Optical Fiber

Extreme waves are often the result of instabilities in nonlinear wave propagation. Furthermore, studies of extreme waves in optics are still almost entirely limited to 1D propagation. Theoretical and experimental studies of spatiotemporal instabilities in multimode propagation will be presented.

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MS4

Burgers Equation with Random Forcing

I will talk about the ergodic theory of randomly forced Burgers equation (a basic nonlinear evolution PDE related to fluid dynamics and growth models) in the noncompact setting. One has to study one-sided infinite minimizers of random action (in the inviscid case), and polymer measures on one-sided infinite trajectories (in the positive viscosity case). Joint work with Eric Cator, Kostya Khanin, Liying Li.

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MS4

Title Not Available

Abstract not available.

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MS4

Scaling of Negative Velocity Gradients in the Stochastic Burgers Equation

After a short review of the instanton formalism and its relation to large deviation theory, I will present recently developed methods to compute instantons (minimizers of the Freidlin-Wentzell functional) in complex systems. For the stochastically driven Burgers equation, I will show that the numerically obtained instantons can be used to correctly characterize the probability distribution of large negative gradients, even in regimes where the asymptotic theory does not apply yet. This is a joint work with Tobias Grafke (NYU), Rainer Grauer (University of Bochum), and Eric Vanden-Eijnden (NYU).

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MS5

Scattering of Nonlinear Schroedinger Equation Without Nonzero Boundary Condition

In this talk, we discuss the long-time behavior of the Nonlinear Schroedinger equation with external potential and non-vanishing boundary condition. Our main motivation is how the scattering detects the external potential.

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MS5

On the Dynamics of Bose Gases and Bose-Einstein Condensates

In this talk, we discuss some results addressing the dynamics of a Bose-Einstein condensate and the quantum fluctuations around it for an approximative model. This is based on joint work with V. Bach, S. Breteaux, J. Froehlich, and I.M. Sigal.

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MS5

The Rigorous Derivation of the 2D Cubic Focusing NLS from Quantum Many-Body Evolution

We consider a 2D time-dependent quantum system of N bosons with harmonic external potential and attractive interparticle interaction in the Gross-Pitaevskii scaling. We derive a new stability of matter type estimate showing that the k-th power of the energy controls the H1 Sobolev norm of the solution over k-particles, by a method different from previous works treating repulsive interactions. By passing to the BBGKY hierarchy, we obtain the focusing nonlinear Schroedinger equation is the mean-field limit.

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MS5

Normal Fluctuations in Quantum Many-Body Systems

I will discuss progress on understanding the fluctuations in quantum many-body systems, showing that they have a normal distribution around the mean-field Hartree solution. I will also discuss connections with quantum de Finetti results and steps towards understanding the rare-event large deviations in quantum many-body dynamics. This is joint work with Gerard Ben Arous and Benjamin Schlein.

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MS6

Long-Time Stability of Standing Waves in Hamiltonian $\mathcal{PT}$-Symmetric Chains of Coupled Pendula

We consider the Hamiltonian version of a $\mathcal{PT}$-symmetric lattice that describes dynamics of coupled pendula perturbed by a periodic resonant movement of their bases. Newton's equations of motion are reduced asymptotically to the $\mathcal{PT}$-symmetric discrete nonlinear Schrödinger equation. In the limit of weak coupling between the pendula, existence of periodic synchronized oscillations supported near one pair of coupled pendula follows by standard bifurcation analysis. If the gain-damping parameter that corresponds to the periodic resonance force is sufficiently small, spectral stability of such synchronized oscillations can be proved within the same limit. As the main contribution, we prove the nonlinear long-time stability of the synchronized oscillations by using the Lyapunov method. The periodic movement of coupled pendula is a saddle point of a constrained Hamiltonian function, which exists between the continuous bands of positive and negative energy. Nevertheless, we construct the approximate Lyapunov function and use it for the proof of nonlinear long-time stability of the synchronized oscillations of the coupled pendula.

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MS6

Multi-Dimensional Stability of Waves Travelling Through Rectangular Lattices in Rational Direction

We consider scalar, bistable lattice differential equations on rectangular lattices in two space dimensions. We show that under certain natural conditions that wave like solutions exist when obstacles (characterized by "holes") are present in the lattice. The results here generalize to spatially discrete problems, the results on propagation through obstacles for partial differential equations due to Berestycki, Hamel and Matano. The analysis hinges upon development of sub and supersolutions for this class of higher space dimension lattice differential equations and on a generalization of a classical result of Aronson and Weinberger on the spreading of localized disturbances.

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MS6

On-Site and Off-Site Solitary Waves of Discrete Nonlinear Schrödinger Type Equations

We construct families of symmetric solitary standing waves to the discrete nonlinear Schrödinger equation (DNLS) with cubic nonlinearity using bifurcation methods about the continuum limit. Such waves play a role in the propagation of localized states of DNLS. Their energy differences, which we prove to be exponentially small in a natural parameter, are related to the Peierls-Nabarro energy barrier in discrete systems, first investigated by M. Peyrard and M.D. Kruskal (1984). We discuss both the nearest-neighbor case and more general long-range (nonlocal) coupling, along with their stability. This is joint work with Michael I. Weinstein.

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MS6

Traveling Waves for the Mass-in-Mass Model of Granular Chains

We consider the problem for existence of traveling waves in the mass-in-mass system. We identify a condition on the parameters, so called anti-resonance condition, which allow us to find a variational solution. In some sub-regimes of the anti-resonance condition, we find waves that are bell-shaped (and hence behave in compacton-like manner), while in other sub-regimes, the solutions may develop some oscillatory behavior. This transition (from bell-shaped to oscillatory) is also observed in numerical simulations.

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MS7

Global Solutions to Self-Similar Transonic Two-Dimensional Riemann Problems

We discuss the recent progresses in transonic problems in multidimensional conservation laws. For two dimensional Riemann problems in compressible gas dynamics, many configurations give rise to self-similar patterns, and the problems change their types near the locus of sonic circles, that is, the problems become transonic. We present the recent results on a simpler model with a certain Riemann data, which gives rise to a transonic shock.

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MS7

Nonlocality and Arrested Fronts in Biological Colony Formation

Biological pattern formation has been extensively studied using reaction-diffusion models. These models are inherently local, however many biological systems are known to exhibit nonlocality. In this talk we will discuss nonlocal pattern forming mechanisms in the context of bacterial colony formation. This will lead to a nonlocal framework to understand arrested fronts in biological systems.

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MS7

Exploring Data Assimilation and Forecasting Issues for an Urban Crime Model

In this talk, we explore some of the various issues that may occur in attempting to fit a dynamical systems (either agent- or continuum-based) model of urban crime to data on just the attack times and locations. We show how one may carry out a regression analysis for the model described by [M.B. Short, et al., Math. Mod. Meth. Appl. Sci. 2008] by using simulated attack data from the agent-based model. It is discussed how one can incorporate the attack data into the partial differential equations for the expected attractiveness to burgle and the criminal density to predict crime rates between attacks. Using this predicted crime rate, we derive a likelihood function that one can maximise in order to fit parameters and/or initial conditions for the model. Finally, we outline future research in this area where we believe that the combination of dynamical systems modelling, analysis, and data assimilation can prove effective in developing policing strategies for urban crime.

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MS7

Structure and Mechanics of Microbial Biofilms

Biofilms are multicellular microbial colonies that are widespread in nature, medicine, and industry. Within biofilms, microbes embedded in a gel-like extracellular matrix exhibit collective behaviors, such as colony spreading and channel formation, which are mediated by local mechanical interactions between bacteria. Here, we will describe the use of fluorescence microscopy and micromechanical measurements to determine local interactions between microbes and their impact on collective phenomena.

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MS8

The Unified Transform Method for Systems of Equations

The Unified Transform Method (UTM) has been successfully applied to a great number of very different problems. Most of these problems have been scalar problems. When dealing with systems of equations, the dispersion relation of the problem is of the same order as the system, which leads to branched frequency functions appearing in the global relation. Most systems that have been approached using the UTM avoid have dispersion relation solutions that are not branched, and as such their solution is not typical. A few systems with branched solutions have been considered, but on an ad hoc basis. I will outline how the UTM can systematically deal with systems of equations without much added effort, compared to the scalar case.

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MS8

A new Transform Approach to Biharmonic Boundary Value Problems in Polygonal and Circular Domains

Motivated by modelling challenges arising in microfluidics and low-Reynolds-number swimming, we present a new transform approach for solving biharmonic boundary value problems in two-dimensional polygonal and circular domains. The method is an extension of earlier work by Crowdy & Fokas [Proc. Roy. Soc. A, 460, (2004)] and provides a unified general approach to finding quasi-analytical solutions to a wide range of problems in low-Reynolds-number hydrodynamics and plane elasticity. [This is joint work with Darren Crowdy].

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MS8

Nonlocal Problems for Linear Evolution Equations

Linear evolution equations, such as the heat and linearized KdV equations, are commonly studied on finite spatial domains with boundary conditions at the edges. Alternatively, consider "multipoint conditions', where one specifies a combination of the solution and its derivatives evaluated at internal spatial points, or the "nonlocal' specification of the integral of the solution against some weight. We describe a general framework for studying such problems, and provide solution representations.

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MS8

A Boundary Value Problem Pertaining to Viscous Water Waves

The study of wind driven surface gravity waves is one of the oldest and challenging topics in fluid flow. In this talk I will introduce a simple model for this problem with the goal of deriving a linear dispersion relation for viscous water-waves *i.e.* the damping rate of a wave with horizontal wave number k. Classical approaches involve either the study of the vorticity equation or employing a Helmholtz decomposition. In the present talk, I will discuss some reasons to avoid either route and suggest the equations are properly analysed using the Uniform Transform Method (UTM). The application of UTM to this problem requires the extension of this method to fourth order, degenerate mixed partial derivative equations. The bulk of the talk will present details of this extension.

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MS9

2-D Gravity-Capillary Solitary Waves Generated by a Moving Pressure Forcing

Dynamics of 2-D gravity-capillary solitary waves generated by a moving pressure forcing on the surface of deep water is investigated theoretically and experimentally. A relevant theoretical model equation is numerically solved for the identification of different wave patterns according to forcing speeds near the minimum phase speed (23 cm/s). In addition, without forcing, the transverse instability of free 2-D gravity-capillary solitary waves is analytically studied based on the linear stability analysis. Finally, these theoretical results are compared with relevant experimental results.

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MS9

Stability of Traveling Waves with Constant Vorticity

Euler's equations describe the dynamics of gravity waves on the surface of an ideal fluid with arbitrary depth. In this talk, we discuss the stability of periodic traveling wave solutions for the full set of Euler's equations with constant vorticity via a generalization of a non-local formulation of the water wave problem due to Ablowitz, *et al.*, and Ashton & Fokas. We determine the spectral stability for the periodic traveling wave solution by extending Fourier-Floquet analysis to apply to the non-local problem. We will discuss some interesting and new relationships between the stability of the traveling wave with respect to long-wave perturbations and the structure of the bifurcation curve for small amplitude solutions.

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MS9

Analyzing the Stability Spectrum for Elliptic Solutions to the Focusing NLS Equation

The one-dimensional focusing cubic nonlinear Schrödinger (NLS) equation is one of the most important integrable equations, arising in a multitude of applications. The stability of the stationary periodic solutions of NLS is well studied, leading to, for instance, the iconic figure-eight spectrum for its cnoidal wave solutions. We present an explicit expression for the linear stability spectrum of both the trivial- and nontrivial-phase solutions. We use this expression to generate many explicit results about the spectrum.

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MS9

Stability of Capillary-Gravity Solitary Waves in Deep Water

The stability of two-dimensional capillary-gravity solitary waves are revisited. We integrate hodograph transformation and time-dependent conformal map, so that the stability characteristics of multi-packet solitary waves, including both symmetric and asymmetric, can be throughly investigated. Stable solitary waves can be excited by moving one or two fully localized pressure with the speed close to the phase speed minimum to mimic the jet of air impinging on the surface of a steady stream. Surprisingly, the overhanging depression waves are found to be stable.

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MS10

The Effect of Strong Wind on Akhmediev Breathers

The Nonlinear Schrödinger Equation (NLSE) can be derived from the Euler equations using the method of multiple scales. To model the effect of wind on the water waves, a forcing term can be added the Euler equations, based on the Miles growth rate Γ_M. We investigate the case $\Gamma_M = \mathcal{O}(\textit{wave steepness})$, which yields additional terms in the NLSE that affect e.g. downshifting and the growth rate of the modulation instability.

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MS10

Photonic Structures Based on Light Filamentation in Air and in Liquids

At first, we discuss the possibilities of guiding, manipulating, and processing radio-and microwave-frequency radiation using photonic structures built of filaments. In particular, we introduce so-called virtual hyperbolic metamaterials formed by an array of plasma channels in air as a result of self-focusing of an intense laser pulse, and show that such structure can be used to manipulate microwave beams in a free space. Generation of virtual hyperbolic metamaterials requires a regular and spatially invariant distribution of plasma channels. Therefore, we discuss the generation of such large regular arrays of filaments and consider the interactions between multiple filaments, multiple filament formation, and phase-controlled structured filaments. Lastly, we present our recent studies of the phenomenon of spatial modulational instability leading to laser beam filamentation in an engineered soft-matter nonlinear medium. The emergence of metamaterials also has a strong potential to enable novel nonlinear light-matter interactions and even new nonlinear materials. In particular, nonlinear focusing and defocusing effects are of paramount importance for manipulation of the minimum focusing spot size of structured light beams necessary for nanoscale trapping, manipulation, and fundamental spectroscopic studies. Colloidal suspensions considered in our study offer as a promising platform for engineering polarizibilities and realization of large and tunable nonlinearities.

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MS10

Instabilities of Wave Turbulence That Initiate the Formation of Coherent Structures

I discuss an instability of wave turbulence that dynamically enhances small correlations of an ensemble of trajectories. This instability gives rise to the formation of localized coherent structures. I discuss this phenomenon for turbulence in one and in two spatial dimensions.

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MS10

Vector Schroedinger Equation: Quasi-Particle Concept of Evolution and Interaction of Solitary Waves

For the system of nonlinear Schroedinger equations (SCNLSE) coupled both through linear and nonlinear terms, we investigate numerically the head-on and taking-over collision dynamics of polarized solitons. In the case of general elliptic polarization, analytical solutions for the shapes of steadily propagating solitons are not available, and we develop an auxiliary numerical algorithm for finding the initial shape. In the majority of cases the solitons survive the interaction, preserving approximately their phase speeds and the main effect is the change of individual polarization but the total net polarization of the system is conserved. The results of this work elucidate the role of the linear and nonlinear couplings, the initial phase, and the initial polarization on the interaction dynamics of soliton systems in SCNLSE.

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MS11

Errors Growing from Noise in the Zeros of a Lightwave Communication System

In optical systems, amplified spontaneous emission noise leads to errors if noise-induced fluctuations are large. We discuss the problem of errors growing from noise when a pulse is absent, i.e., when a zero has been sent in a return-to-zero system. We show that the most probable large deviations arise due to an interplay between nonlinear propagation of the noise and the detector used at the end of the transmission line to recover the transmitted signal.

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MS11

A probabilistic Decomposition-Synthesis Method for the Quantification of Rare Events in Nonlinear Water Waves

We consider the problem of probabilistic quantification of dynamical systems that have heavy-tailed characteristics. These heavy-tailed features are associated with rare transient responses due to the occurrence of internal instabilities. We develop a probabilistic decomposition-synthesis method that takes into account the nature of internal instabilities to inexpensively determine the non-Gaussian probability density function for any arbitrary quantity of interest. We demonstrate our approach in nonlinear envelope equation characterizing the propagation of unidirectional water waves.

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MS11

Biased Monte Carlo Simulations to Compute Phase Slip Probabilities in a Mode-Locked Laser Model

We consider the probability that a mode-locked laser with active feedback will experience a phase slip when subjected to small-amplitude random perturbations such as amplified spontaneous emission noise generated by the gain medium. To quantify the likelihood of this rare event, we reduce the infinite-dimensional model to a finite-dimensional system of stochastic ordinary differential equations (SODE) and study optimal paths computed using the geometric minimum action method, including using these paths in biased Monte Carlo simulations.

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MS12

On the Pair Excitation Function

We will review the history of the rigorous theory of the pair excitation function approximating the evolution of a coherent state, and describe most recent results for a Hamiltonian with two body interaction potential $N^{3\beta-1}v(N^{\beta(x-y)})$, with $\beta < 2/3$. This is joint work with M. Grillakis.

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MS12

Aspects of Pair Excitations in Bose-Einstein Condensation

This talk focuses on recent advances and challenges in the mathematical modeling of effects that go beyond the usual mean-field limit of quantum dynamics in dilute Boson gases at very low temperatures. Of particular interest is the effect of pair excitation, by which Bosons are scattered off the lowest macroscopic state in pairs. Aspects of this mechanism will be described for trapped dilute gases at zero and finite but small temperatures.

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MS12

Regularity Properties of the Cubic Nonlinear Schroedinger Equation on the Half Line

In this talk I will describe how one can derive local and global regularity properties for the cubic nonlinear Schroedinger equation on the half line with rough initial data. These properties include local and global wellposedness results, local and global smoothing results and the behavior of higher order Sobolev norms of the solutions. Our methods are quite general and apply to a variety of initial/boundary value dispersive equations and systems of equations. The work is joint with B. Erdogan.

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MS12

Waves in Honeycomb Structures

We first review the properties of waves in honeycomb structures such as graphene and its photonic analogues. We then focus on recent results on edge states. These are modes which propagate parallel to a line-defect or edge, and are localized transverse to it. Certain edge states are topologically protected ; they are stable against localized (even large) perturbations. This strong stability is closely related to a robust zero-energy eigenmode of an effective Dirac operator. A key condition for the existence of protected edge states is the "spectral no-fold condition for the prescribed edge, a property of the bulk honeycomb structure. This is joint work with C. L. Fefferman and James P. Lee-Thorp.

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MS13

Dirac Points and Conical Diffraction in Hexagonally Packed Granular Crystal Lattices

Linear and nonlinear mechanisms for conical wave propagation in a statically compressed granular lattice of spherical particles arranged in a hexagonal packing configuration is analyzed. Analysis both via a heuristic argument for the linear propagation of a wave packet and via asymptotic analysis leading to the derivation of a Dirac system suggests the occurrence of conical diffraction. This analysis is valid for strong precompression, i.e., near the linear regime. For weak precompression, conical wave propagation is still possible, but the resulting expanding circular wave front is of a nonoscillatory nature, resulting from the complex interplay among the discreteness, nonlinearity, and geometry of the packing.

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MS13

On Long Time Dynamics of Small Solutions of Discrete Nonlinear Schrodinger Equations

In this talk, we study the long time dynamics of discrete nonlinear Schrödinger equations with potential. We consider the case that the corresponding Schrödinger operator has two eigenvalues. In this case, under a non-resonant condition, we can show that there exists a family of quasi-periodic solutions. Further, we show that all small solutions locally converges to one of these quasi-periodic solutions.

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MS13

Generalized dNLS Models as Normal Forms for KG Lattices and Applications

Generalized dNLS models emerge as resonant normal forms for Klein-Gordon lattices in the small energy regime and anticontinuum limit. In the case of an arbitrary large but finite 1D lattice, the use of discrete symmetries allow to get a sharp dependence of the estimates on the size of the lattice. Results available on the generalized dNLS lattices, like long time stability of breathers, approximation of the Cauchy problem and non existence of vortex-like multibreathers can be transfered to the original Klein-Gordon lattice.

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MS13

Pulse and Defect Dynamics in Cellular Automaton Models for Excitable Media

Probably the first cellular automaton model for excitable media goes back to Wiener and Rosenblueth in the 40's. In the late 70's Greenberg and Hastings suggested a somewhat extended simple cellular automaton hierarchy for an excitable medium and explored its dynamics and relations to the Fitz-Hugh-Nagumo model. Durret and Steiff studied statistical properties of the simplest 3-state automaton in discrete 1D and 2D setting in the early 90's, in particular they determined the entropy in 1D. In this talk we pick up these results and interpret them in view of nonlinear waves and defects, and discuss some directions and open problems. This is joint work with Dennis Ulbrich (Uni Bremen).

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MS14

Modulational Stability of Periodic Waves of the Kawahara Equation

Kawahara equation is a generalization of Kortweg-de Vries equation which models capillary-gravity waves in shallow water. In this talk, we explore the the stability of periodic waves, and especially when the perturbation has a characteristic length much longer than the wavelength of the periodic wave. To this end, we study the corresponding Whitham modulation equations.

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MS14

Stability of Traveling Waves and the Maslov Index

The Maslov index has been used extensively in the stability analysis of nonlinear waves. While theoretical results exist relating it to the Morse index of linear operators, calculating the index has remained a significant challenge. We will address this problem using a generalized FitzHugh-Nagumo model as an example. The presence of two time scales in these equations allows us to use geometric constraints of phase space to compute the index. Furthermore, this model is the quintessential activator-inhibitor system, which means that the relevant evolution equation is non-Hamiltonian.

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MS14

Maslov Index and the Spectrum of Differential Operators

We study the spectrum of the Schrödinger operators with $n \times n$ matrix valued potentials on a finite interval subject to $\theta-$periodic boundary conditions. For two such operators, corresponding to different values of θ, we compute the difference of their eigenvalue counting functions via the Maslov index of a path of Lagrangian planes. In addition we derive a formula for the derivatives of the eigenvalues with respect to θ in terms of the Maslov crossing form. Finally, we give a new shorter proof of a recent result relating the Morse and Maslov indices of the Schrödinger operator for a fixed θ.

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MS14

Hadamard-Type Formulas Via the Maslov Form

Given a star-shaped bounded Lipschitz domain $\Omega \subset R^d$, we consider the Schrödinger operator $L_{\mathcal{G}} = -\Delta + V$ on Ω and its restrictions $L_{\mathcal{G}}^{\Omega_t}$ on the subdomains Ω_t, $t \in [0, 1]$, obtained by shrinking Ω towards its center. We impose either the Dirichlet or quite general Robin-type boundary conditions determined by a subspace $\mathcal{G}$ of the boundary space $H^{1/2}(\partial\Omega) \times H^{-1/2}(\partial\Omega)$, and assume that the potential is smooth and takes values in the set of symmetric $(N \times N)$ matrices. Two main results are proved: First, for any $t_0 \in (0, 1]$ we give an asymptotic formula for the eigenvalues $\lambda(t)$ of the operator $L_{\mathcal{G}}^{\Omega_t}$ as $t \to t_0$ up to quadratic terms, that is, we explicitly compute the first and second t-derivatives of the eigenvalues. This includes the case of the eigenvalues with arbitrary multiplicities. Second, we compute the first derivative of the eigenvalues via the (Maslov) crossing form utilized in symplectic topology to define the Arnold-Maslov-Keller index of a path in the set of Lagrangian subspaces of the boundary space. The path is obtained by taking the Dirichlet and Neumann traces of the weak solutions of the eigenvalue problems for $L_{\mathcal{G}}^{\Omega_t}$.

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MS15

Initial-Boundary Value Problems for a Class of Non-Local Evolution PDEs

We implement the unified transform method to study initial-boundary value problems for a class of non-local evolution PDEs. After formulating the general theory, we discuss several examples, comparing the results with those arising for standard evolution PDEs.

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MS15

The Initial-Boundary Value Problem for Dispersive Equations

In this talk we consider the initial-boundary value problem (ibvp) for linear and nonlinear dispersive equations on the half-line with data in Sobolev spaces. The basic models are the Korteweg-de Vries and the nonlinear Schrödinger equations together with their linear parts. First, we shall recall the solution formulas for linear forced ibvp obtained by using the unified transform method. Then, we shall present the basic space and time estimates for the linear problem when the initial and boundary data belong in Sobolev spaces. Finally, using these estimates and solution spaces and norms that are motivated by the nonlinearity we shall prove well-posedness of the corresponding nonlinear ibvp for data belonging in Sobolev spaces with appropriate exponents. The talk is based on work in collaboration with Athanassios S. Fokas and Dionyssios Mantzavinos.

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MS15

Computation of Water Waves Through a Non-Local Formulation

We discuss a non-local formulation for the classical equations of rotational water waves, which is based on the so-called *unified transform* or the Fokas method. This method provides a novel approach for the analysis of linear and integrable nonlinear boundary value problems In this talk we use asymptotic techniques to compute the free boundary of two-dimensional, periodic, rotational traveling water waves, over a flat bottom. We present results that associate the wave height and the shape of the free boundary, with the different values of the vorticity.

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MS16

Stability and Topology for Dynamics on Networks

We consider several models of dynamics on networks, included the Kuramoto model for the synchronization of coupled oscillators. We are particularly interested in the interaction between the stability properties of the steady state solutions and the topological properties of the underlying interaction graph. We prove a duality result that reduces the stability computation to one on the cycle space of the graph.

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MS16

Benjamin-Feir instability of Stokes Waves

I will discuss spectral properties of the linearized operator associated with the water wave problem in two dimensions in finite depths in the vicinity of the origin of the spectral plane. In particular I will make an alternative proof, to that of Bridges and Mielke, of the celebrated Benjamin-Feir instability of Stokes waves to long wavelength perturbations. The proof is based upon a reformulation of the problem into nonlinear nonlocal equations via conformal mapping and makes use of perturbation arguments, and it may be useful to studies of the spectrum away from the origin.

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MS16

Three Dimensional Traveling Waves in Vortex Sheets

Techniques for computing extremely steep traveling waves at the interface between two fluids are presented. These waves are periodic solutions of the vortex sheet formulation of the potential flow equations. Utilizing the small-scale decomposition for the fluid velocity (Ambrose, Siegel & Tlupova, 2013), an extension of the travelling wave ansatz (Akers, Ambrose & Wright, 2013) and an isothermal parameterization of the interface, three-dimensional traveling waves are computed via numerical continuation methods in parameter space.

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MS16

Subharmonic Stability and Quasi-Periodic Perturbations of Traveling and Standing Water Waves

We combine Floquet theory in time and Bloch theory in space to study the stability of traveling and standing water waves subject to harmonic and subharmonic perturbations. For the latter, we have developed new boundary integral and conformal mapping methods for the spatially quasi-periodic Dirichlet-Neumann operator. We conclude with a discussion of general quasi-periodic solutions of the free-surface Euler equations and present preliminary calculations of some simple cases.

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MS17

Smooth Tails of Self-Similar Pulses

Pulses propagating in a Kerr medium with gain follow self-similar dynamics with a parbolic intensity profile. However, the sharp corners implied by the limiting shape are smoothened at finite propagation distance. We show that the tails have a universal shape described by the Painleve II equation, and that they are self-similar with expnonents different from the main pulse.

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MS17

Near to Mid-Infrared Supercontinuum and Frequency Comb Generation

Abstract not available.

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MS17

Existence, Stability AndDynamics of Discrete Solitary Waves in a Binary Waveguide Array

We examine the anti-continuum limit in a binary waveguide arrays. By developing a general theory which systematically tracks down the key eigenvalues of the linearized system, we will provide a systematic discussion of states involving one, two and three excited waveguides. When we find the states to be unstable, we explore their dynamical evolution through direct numerical simulations. The latter typically illustrate, for the parameter values considered herein, the persistence of localized dynamics and the emergence for the duration of our simulations of robust quasi-periodic states for two excited sites. As the number of excited nodes increase, the unstable dynamics feature

less regular oscillations of the solution's amplitude.

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MS17

Noise Properties of Frequency Combs Based on Normal-Dispersion Fiber Lasers

Frequency combs based on modelocked fiber lasers are studied theoretically and experimentally. The roles played by cavity dispersion, pulse evolution, and pulse energy in determining the properties of the comb will be presented.

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MS18

Numerical Simulations of Biological Invasions

Biological invasions occur when there is a road on which an epidemic propagates faster than in the outlying fields adjacent to the roads. These types of invasions can be modeled using reaction-diffusion equations with varying parameters on the roads and in the outlying areas with coupling between the two. We will present a numerical method to study this problem. Comparisons with previous analytical work with a straight road will be presented. Also, numerical simulations considering more complex reactions and road shapes will be discussed.

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MS18

Cytoplasmic Flows as Signatures for the Mechanics of Mitotic Positioning

An essential first step in eukaryotic development is migration and proper positioning of the pronuclear complex (PNC) within the cell. We present the first full simulations of PNC migration that capture the interactions of O(1000) centrosomal microtubules (MTs) with the cytoplasm, the cell periphery, and PNC, and demonstrate two key consequences of hydrodynamic interactions (HIs) on PNC migration. We show that previous estimates of the PNC drag that ignore or partially include HIs, lead to misestimation of the active forces by an order of magnitude. We then study the dynamics of PNC migration under various biophysical models, including the cortical pushing or pulling of MTs, and pulling on MTs by cytoplasmic force generators. While achieving proper positioning does not choose a model, we find that each proposed mechanism produces unique differentiating flow signatures. This study is made possible through a highly efficient, custom framework for simulating cytoskeletal assemblies.

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MS18

Stable and Low Resolution Simulations in Interfacial Dynamics

Simulating problems with fluid-structure interactions poses several numerical challenges such as non-local interactions, stiffness, and strong non-linearities. These challenges make simulations with long time horizons particularly challenging, especially at low resolutions. In order to maintain stability for long time horizons, several algorithms such as anti-aliasing, reparameterization, and time adaptivity are necessary. We will closely examine the effects that these algorithms have on the physics of the interfacial flow.

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MS18

A Fast Platform for Simulating Fluid-Structure Interactions in Cytoskeletal Assemblies

We present a novel platform for the large-scale simulation of fibrous structures immersed in a Stokesian fluid, customized for studying the dynamics of subcellular fibrous assemblies. We incorporate fibers polymerization/depolymerization, their interactions with molecular motors, their flexibility, and hydrodynamic coupling. We model three active mechanisms proposed for positioning of mitotic spindle during the early cell divisions in Caenorhabditis elegans, and their consequent unique flows. We demonstrate that nonlocal hydrodynamics is an essential feature of positioning.

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MS19

A Dynamic Phase-Field Model for Structural Transformations and Twinning: Regularized Interfaces with Transparent Prescription of Complex Kinetics and Nucleation

Phase-field models enable easy computations of microstructure because they regularize sharp interfaces. In addition, the nucleation of new interfaces and the kinetics of existing interfaces occurs "automatically" using only the energy and a gradient descent dynamics. This automatic nucleation and kinetics is often cited as an advantage of these models, and is not present in sharp interface approaches where nucleation and kinetics must be explicitly prescribed. However, this is not necessarily an advantage. Rather, it does not allow us to use nucleation and kinetic insights that may be gained from experiment and/or molecular simulations. Hence, this feature is actually a disadvantage because it breaks the multiscale modeling hierarchy of feeding information through the scales. Motivated by this, we have developed a phase-field model (i.e., with regularized interfaces) that allows for easy and transparent prescription of kinetics and nucleation. We present the formulation of the model, and characterization through various examples.

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MS19

Adiabatic and Isothermal Phase Boundaries in Mass-Spring Chains

Mass-spring chains with only extensional degrees of freedom have provided insights into the behavior of crystalline solids, including those capable of phase transitions. Here we add rotational degrees of freedom to the masses in a chain and study the dynamics of phase boundaries across which both the twist and stretch can jump. We solve impact and Riemann problems in the chain by numerical integration of the equations of motion and show that the solutions are analogous to those in a phase transforming rod whose stored energy function depends on both twist and stretch. From the dynamics of phase boundaries in the chain we extract a kinetic relation whose form is familiar from earlier studies involving chains with only extensional degrees of freedom. However, for some combinations of parameters characterizing the energy landscape of our springs we find propagating phase boundaries for which the rate of dissipation, as calculated using isothermal expressions for the driving force, is negative. Keeping this in mind we define a local temperature of our chain and show that it jumps across phase boundaries, but not across sonic waves. Hence, impact problems in our mass-spring chains are analogous to those on continuum thermoelastic bars with Mie-Gruneisen type constitutive laws.

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MS19

Nonlinear Waves in Traffic Flow

Initially homogeneous vehicular traffic flow can become inhomogeneous even in the absence of obstacles. In this "phantom traffic jam' phenomenon, small perturbations grow into traveling waves. We demonstrate that these waves, called "jamitons', can be described as nonlinear detonation waves in second-order macroscopic traffic models. We investigate the behavior of jamitons, in particular their interaction and long-term evolution. Moreover, we discuss to which extent these waves could be dissipated, or prevented from arising, via traffic control (ramp metering, adaptive speed limits) or via autonomous vehicles that will enter our roadways in the near future.

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MS19

Solitary Waves and Phase Boundaries in Peridynamics

Abstract not available.

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MS20

Traveling Waves in Diatomic Fermi-Pasta-Ulam-Tsingou Lattices

We discuss traveling waves for diatomic Fermi-Pasta-Ulam-Tsingou (FPUT) lattices consisting of two distinct masses and only one kind of spring. After diagonalizing certain operators in the traveling wave equations, the resulting system becomes highly amenable to the technique of bifurcation from a simple eigenvalue due to Crandall, Rabinowitz, and Zeidler. For the purpose of subsequent analysis, however, we require rather precise estimates on the solutions, and these estimates must be uniform over wave speeds close to the speed of sound. Therefore, we exploit the "diagonal" nature of the problem and obtain both the solutions and the uniform estimates via a fixed-point analysis, still inspired by the proofs of classical bifurcation. This is joint work with J. Douglas Wright.

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MS20

Edge States in Continuous and Discrete Systems

Edge states are time-harmonic solutions to energy-conserving wave equations, which are propagating parallel to a line defect or "edge" and are localized transverse to it. In this talk, we discuss the connection between edge states in continuous and (discrete) tight-binding edge models in the Schrödinger setting. We begin by outlining a bifurcation theory of topologically protected and non-protected edge states in continuous 2D honeycomb structures, before discussing analogous edge state results in the tight-binding limit.

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MS20

Discrete Breathers in Honeycomb Fermi-Pasta-Ulam Lattices

We analyse a two dimensional Fermi-Pasta-Ulam lattice with honeycomb structure. We use asymptotic techniques to obtain an approximation for a breather mode in the form of a envelope enclosing a linear wave. This yields conditions on the form of the nonlinearity in the lattice and the wavenumbers of the linear mode. We comment on the relationship between this, the square and the triangular 2D lattices.

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MS20

Nonlinear Wave Transmission Thresholds in Disordered Periodic Structures

We study wave transmission through a finite damped nonlinear periodic structure, subjected to continuous harmonic excitation at one end. Nonlinearity leads to supratransmission, whereby enhanced wave transmission occurs within the stopband of periodic structures when forced at amplitudes exceeding a threshold. We study supratransmission in the presence of deviations from periodicity (small variations in stiffness parameters throughout the structure). The force threshold remains unchanged in the ensemble-average sense, but the transmitted wave energy is reduced.

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MS21

Phase Dynamics, Modulation and Water Waves

The derivation of modulation equations via modulation will be discussed. The principal example is the KP equation near a periodic travelling wave. Applications to water waves will be discussed.

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MS21

Kinematics of Fluid Particles on the Sea Surface: Symplecticity and Vorticity

I will show that the John-Sclavounos equations describing the motion of a fluid particle on the sea surface can be derived from first principles. In particular, the equations follow from the Lagrangian and Hamiltonian formalisms applied to the motion of a frictionless particle constrained on an unsteady surface. The main result is that vorticity generated on a stress-free surface vanishes at a wave crest when the horizontal particle velocity equals the crest propagation speed, which is the kinematic criterion for wave breaking. If this holds for the largest crest, then the symplectic two-form associated with the Hamiltonian dynamics reduces instantaneously to that associated with the motion of a particle in free flight, as if the surface did not exist. Implications of these theoretical results for wave breaking are discussed.

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MS21

Traveling Wave Solutions of Fully-Discrete Multi-Symplectic Equations

Infinite dimensional functional equations describe the traveling wave solutions of multisymplectic discretizations of PDEs. Sometimes the discrete traveling waves can be calculated exactly, or to high accuracy using Fourier series. Otherwise, backward error analysis allows a study of the discrete traveling waves through an ODE that describes the behavior. The analysis can be applied to various multisymplectic discretizations for many PDEs, providing a deeper understanding of the advantages and disadvantages of using multisymplectic integrators.

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MS21

Modulation and the Zig-Zag Instability for Gradient Reaction-Diffusion Equations

Using a second order Matrix PDE framework, it is shown that the phase diffusion equation emerges via modulation with universal coefficients (that is, they are related to the steady conservation law). When this degenerates, a nonlinear phase equation arises describing zig-zag dynamics. An example of how this system arises is given in the context of the Swift-Hohenberg equation.

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MS22

Instability of Steep Ocean Waves and Whitecapping

Wave breaking in deep oceans is a challenge that still defies complete scientific understanding. Sailors know that at wind speeds of approximately 5m/sec, the random looking windblown surface begins to develop patches of white foam (whitecaps) near sharply angled wave crests. We idealize such a sea locally by a family of close to maximum amplitude Stokes waves and show, using highly accurate simulation algorithms based on a conformal map representation, that perturbed Stokes waves develop the universal feature of an overturning plunging jet. We analyze both the cases when surface tension is absent and present. In the latter case, we show the plunging jet is regularized by capillary waves which rapidly become nonlinear Crapper waves in whose trough pockets whitecaps may be spawned.

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MS22

Necklace Solitary Waves on Bounded Domains

The critical power for collapse appears to place an upper bound on the amount of power that can be propagated by intense laser beams. In various applications, however, it is desirable exceed this limit and deliver more power. In this talk I will present new solitary waves of the two-dimensional nonlinear Schrodinger equation on bounded domains, which have a "necklace' structure. I will consider their structure, stability, and how to compute them. In particular, I will show that these solitary waves can stably propagate more than the critical power for collapse.

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MS22

The Causes of Metastability and their Effect on Transition Times

Deterministic equations such as a wave equation with nonlinear forcing can display metastability when considering stochastic initial conditions. Metastability refers the system spending extended periods of time relative to its natural time scale in localized regions of phase space, transiting infrequently between them. Typically thought to be caused by overcoming an energy barrier, I will show how narrow passages in phase space can also cause metastability, and derive the effect on the mean transition time.

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MS22

Nonlinear Waves in Periodic Quantum Graphs

The nonlinear Schrödinger (NLS) equation is considered on a periodic metric graph subject to the Kirchhoff boundary conditions. Bifurcations of standing localized waves for frequencies lying below the bottom of the linear spectrum of the associated stationary Schrödinger equation are considered by using analysis of two-dimensional discrete maps near hyperbolic fixed points. We prove existence of two distinct families of small-amplitude standing localized waves, which are symmetric about the two symmetry points of the periodic graphs. We also prove properties of the two families, in particular, positivity and exponential decay. The asymptotic reduction of the two-dimensional discrete map to the stationary NLS equation on an infinite line is discussed in the context of the homogenization of the NLS equation on the periodic metric graph. This is a joint work with Guido Schneider (University of Stuttgart).

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MS23

Resonant Coupling Between Internal Waves and Surface Waves in the Ocean

Large-amplitude internal waves and their accompanying surface ripples have been observed in many field observations. However, the mechanism for this coupling phenomena has not been completely understood. We develop a weakly nonlinear model in a two-layer density-stratified fluid. Surface waves, characterized by both modulation and resonance, show their asymmetric behavior in spatiotemporal manifestation when an internal soliton passes beneath. Our results may explain the narrow bands of roughness and mill pond effects in experimental observations.

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MS23

Reduced One-Dimensional Turbulence Model and Applications to Filtering

Knowledge of the state of turbulent signals is of particular interest in numerous contexts including science and engineering. An effective mathematical solution estimates the system state and uncertainty associated with it through combining the evolving probability distribution of the underlying system along with available observations: the problem of filtering. In the practical applications of filtering, one frequently encounters the necessity of large dimensional uncertainty quantification due to the fundamental difficulty in describing the complexity phenomena with a small number of degrees of freedom. Traditional algorithms for filtering unfortunately do not perform well under this circumstance. One approach to disable the obstacles in high dimension is to find effective dimension reduction procedure for the probability distribution of the underlying state space model. One of the methodologies to do this is via approximating the original equation for each Fourier mode by an independent and exactly solvable stochastic differential equation. In this paper we introduce a new rigorous methodology for this simplification of underlying system through decoupling within the context of the extended Majda-McLaughlin-Tabak turbulence model.

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MS23

Effective Dispersion in the Nonlinear Schroedinger Equation

When one considers only the linear part of the Nonlinear Schrödinger Equation (NLS) ($iq_t = q_{xx}$), one finds dispersion relation $\omega = k^2$. We don't expect solutions to the fully nonlinear equation to have any kind of effective dispersion relation like this. However, I have seen that solutions to the NLS actually appear to be weakly coupled and are often nearly sinusoidal in time with a dominant frequency, often behaving similarly to modulated plane waves.

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MS23

Waveaction Spectra for Fully Nonlinear Majda-McLaughlin-Tabak Model

We investigate a version of the Majda-McLaughlin-Tabak model of dispersive wave turbulence where the linear term in the time derivative is removed. We consider driven-damped and undriven, undamped cases of the model. Our theoretical predictions for the waveaction spectrum, which are made using statistical mechanical methods as well as arguments reminiscent of Kolmogorov's theory of turbulence, are found to agree with time dynamics simulations.

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MS24

Kerr, Raman and Brillouin Optical Frequency Combs: An Overview

Whispering gallery mode resonators allow to study the light-matter interactions induced by the confinement of photons in nonlinear media. In particular, Brillouin, Raman and Kerr nonlinearities excite the resonator at the lattice, molecular and electronic scale. This versatility gives to whispering gallery-mode resonators the potential to be central photonic components in microwave photonics, quantum optics and optoelectronics. We investigate the fundamental properties of Kerr, Raman and Brillouin frequency combs and discuss some applications.

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MS24

Universal Dynamics and Controlled Switching of Dissipative Kerr Solitons in Optical Microresonators

Formation of dissipative Kerr solitons in optical microresonators has recently been demonstrated, which enables a fully coherent microresonator frequency comb. However, the soliton physics remains largely unexplored. Here, we report, for the first time, the discovery of a novel mechanism that allows to deterministically induce transitions between soliton states. Moreover, we develop a monitoring scheme for in-situ characterization of soliton dynamics. These provide a toolbox for controlled switching to single-soliton states imperative for many applications.

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MS24

Modeling of Frequency Comb Generation in Dispersive Quadratic Cavities

We theoretically investigate frequency comb formation in cavity enhanced second harmonic generation. We show that, in both the singly and doubly resonant configurations, a single mean field equation allows describing the full temporal and spectral dynamics of the resonator. We find excellent agreement with recent experimental results and show that the emergence of frequency combs (and corresponding temporal patterns) is underpinned by a new kind of modulation instability, induced by the strong walk-off.

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MS24

Soliton Generation in High-Q Silica Microcavties

Abstract not available.

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MS25

Structure Formation in Biofilms and Implications

Biofilms are collections of microbes anchored together into sessile communities by self secreted polymers. Though they are in a sense chemical factories, the realities of biofilms as physical materials are important to their function. This talk will present a review of some of what is known about biofilm physics, particularly in the context of biofilm modeling. The focus will be on the importance of diffusive transport limitation and implications for mechanics.

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MS25

How Focused Flexibility Maximizes the Thrust Production of Flapping Wings

Birds, insects, and fish all exploit the fact that flexible wings or fins generally perform better. It is not clear, though, how to best distribute flexibility: Should a wing be uniformly flexible, or should certain sections be more rigid than others? I will discuss this question by using a 2D small-amplitude model combined with an efficient Chebyshev PDE solver. Numerical optimization shows that concentrating flexibility near the leading edge of the wing maximizes thrust production.

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MS25

Effect of Fluid Resistance on Sperm Motility

Micro-organisms can swim in a variety of environments, interacting with chemicals and other proteins in the fluid. Some of these extra proteins or cells may act as friction, possibly preventing or enhancing forward progression of swimmers. The homogenized fluid flow is assumed to be governed by the incompressible Brinkman equation, where a friction term with a resistance parameter represents a sparse array of obstacles. Representing the swimmers with a centerline approximation, we employ regularized fundamental solutions to investigate swimming speeds, trajectories, and interactions of swimmers. Asymmetric waveforms due to an increase in flagellar calcium is known to be important for sperm to reach and fertilize the egg. The trajectories of hyperactivated swimmers are found to have a decreased path curvature. Although attraction of two swimmers is more efficient in the Stokes regime, we find that attraction does not occur for larger resistance.

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MS25

A Dynamical System for Interacting Flapping Swimmers

We present the results of a theoretical investigation into the dynamics of interacting flapping swimmers. Our study is motivated by recent experiments using a one-dimensional array of wings in a water tank. We develop a discrete dynamical system that models the swimmers as airfoils shedding point vortices, and study the existence and stability of steady solutions. Our model may be used to understand how schooling behavior is influenced by hydrodynamics in more general contexts.

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MS26

Neumann Homogenization via Integro-Differential Operators

Abstract not available.

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MS26

Twisted Waves, Orbital Angular Momentum and the Determination of Atomic Structure

We find exact solutions of Maxwell's equations that are the precise analog of plane waves, but in the case that the translation group is replaced by the Abelian helical group. These waves display constructive/destructive interference with helical atomic structures, in the same way that plane waves interact with crystals. We show how the resulting far-field pattern can be used for structure determination. We test the method by doing theoretical structure determination on the Pf1 virus from the Protein Data Bank. The underlying mathematical idea is that the structure is the orbit of a group which is a subgroup of the invariance group of the differential equations. Joint work with Dominik Juestel and Gero Friesecke. (DJ, GF, RJ, Bragg-Von Laue diffraction generalized to twisted X-rays, Acta Crystallographica A72; GF, RJ, DJ, Twisted X-rays: incoming waveforms yielding discrete diffraction patterns for helical structures, SIAM J. Appl Math, accepted).

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MS26

Multiscale Analysis of Nonlocal Evolution Equations

Abstract not available.

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MS26

Calculus of Variations Methods in Nonlocal Theories

Abstract not available.

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MS27

Rattling in Spatially Discrete Diffusion Equations with Hysteresis

We discuss a reaction-diffusion equation with hysteretic nonlinearity on a one-dimensional lattice. It arises as a result of the spatial discretization of the corresponding continuous model with so-called nontransverse initial data and exhibits a propagating microstructure, which we call rattling. We analyze this microstructure and determine its propagation speed.

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MS27

Understanding Pollution with Wiener-Hopf Lattice Factorizations

We study optimal control problems with time delays posed on lattices, which can be used to weigh the costs and benefits of utilizing polluting agents to enhance crop yields. The conditions defining optimal strategies turn out to be Hilbert-space valued functional differential equations of mixed type (MFDEs). We develop tools such as exponential dichotomies and Wiener-Hopf factorizations for such systems to determine whether optimal strategies can retain their optimality under small variations in their initial conditions. Complications are caused by the fact that the modelling state space is only half of the natural mathematical state space.

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MS27

Pacemakers in a 2-D Array of Oscillators with Radially Symmetric Non-Local Coupling

We study a toy model describing a 2-d array of oscillators with nonlocal, radially symmetric, diffusive coupling. The model is close in spirit to an eikonal equation which models oscillatory chemical reactions. We use this information together with the Fredholm properties of the linearization to show that a small patch of oscillators, modeled here as a localized perturbation, can lead to either target patterns or contact defects depending on the sign of the perturbation.

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MS27

Bistable Traveling Waves Under Discretization: BDF and Moving Mesh Methods

I this talk we consider the impact of discretization on traveling wave solutions of reaction-diffusion equations with bistable nonlinearities. Although much is known about traveling waves to such PDEs most analysis related to discretization is for uniform spatial meshes that maintain a translation invariance. In this talk we consider the impact of temporal discretization using backward differentiation formula (BDF) methods and on moving mesh spatial discretizations that seek to equidistribute the error due to spatial discretization.

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MS28

Dark-Bright Solitons and Their Two-Dimensional Counterparts in Coupled Nonlinear Schrodinger Systems

In this talk, we will present a two-component NLS system in one and two spatial dimensions with equal, repulsive cubic interactions and different dispersion coefficients in the two components. We will consider states that support a dark solitary wave (or, equivalently, a vortex in 2D) in the one-component, and explore the possibility of the formation of bright solitonic bound states in the other component. Initially, based on the linear limit for the bright component, we identify bifurcation points of such states and explore their continuation in the nonlinear regime afterward. Then, we will identify regimes of potential stability (in the realm of linear stability analysis) for the single-peak ground state (the dark-bright soliton in 1D and vortex-bright soliton in 2D) as well as excited states with one or more zero crossings in the bright component. Finally, for unstable such states, we will demonstrate results on direct numerical simulations and discuss the dynamics of the instability. This is joint work with Panayotis G. Kevrekidis, Boris A. Malomed and Dimitri J. Frantzeskakis.

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MS28

The Small Dispersion Limit for the Defocusing NLS Equation with Cosine Initial Condition

We employ the WKB method to the scattering problem for the defocusing nonlinear Schrodinger (NLS) equation to study the small dispersion limit with cosine initial conditions, and we apply the results to characterize analytically some recent experiments in nonlinear optics. This work generalizes our recent results on the KdV equation and the Zabusky-Kruskal experiment.

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MS28

Willmore Flow Regime in the Defocusing PNLS

Optical Parametric Oscillators are modeled in a large pump-detuning regime by the parametrically forced NLS (PNLS) equation. In the limit of slow evolution the PNLS reduces to the phase sensitive amplification (PSA) model, a fourth order parabolic equation. The PSA is typically studied in a regime analogous to the focusing PNLS, however the PNLS reduction to PSA also applied in the defocusing regime, leading to a defocusing PSA which is equivalent to the L^2 gradient flow of the functionalized Cahn-Hilliard (fCH) equation. Thus defocusing PNLS, which describes the evolution of π-phase fronts in OPOs also models the evolution of amphiphilic phase separation in charged polymer/solvent mixtures. We derive the relationship between the two systems, and port the results for the fCH to the OPO setting, deriving the Willmore flow in the sharp interface limit.

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MS28

Non-Holonomic Constraints and Discretizations in Klein-Gordon Equations

We explore a new type of discretizations of Klein-Gordon lattice dynamical models. The discretization is based on non-homonomic constraints and is shown to retrieve the "proper' continuum limit of the model. Such discretizations are useful in preserving a discrete analogue of the momentum. For generic initial data, the momentum and energy conservation laws cannot be achieved concurrently. Our approach is suited for cases where an accurate description of mobility for nonlinear traveling waves is important.

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MS29

Energy Based Discontinuous Galerkin Methods for Nonlinear Waves

We present a strategy for the spatial discontinuous Galerkin discretization of nonlinear wave equations in second order form. The method features a direct, mesh-independent approach to defining interelement fluxes. Both energy-conserving and upwind discretizations can be devised. The proposed discretization for equations in second order form arises naturally from a general formulation based directly on the Lagrangian, which is central to the formulation of wave equations in most physical settings. In this talk we also consider the generalization of the discretization to integrable systems of PDE in first order form.

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MS29

Circular Instability of Surface Waves: Numerical and Wavetank Experiments

We compare numerical simulation of instability of weakly nonlinear standing waves on the surface of deep fluid in the framework of the primordial dynamical equations and in a laboratory wave tank experiment. The instability offers a new approach for generation of nearly isotropic spectrum using parametric excitation. Direct measurements of spacial Fourier spectrum confirm existence of the instability in a real life conditions for gravity-capillary waves.

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MS29

Effective Dispersion and Resonant Interactions in Wave-Like Dynamical Systems

Effective dispersion in extended systems may be generated by the increasing nonlinearity, with resonant wave-wave interactions appearing or disappearing, and resonant manifolds deforming. This occurs even in systems with no linear dispersion. In such a subcase of the MMT model, due to its symmetry, we calculated energy and wavenumber spectra both directly and from the wave-turbulence theory associated with the effective dispersion relation. For the NLS equation, we computed this relation to be a quadratic.

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MS29

Spectral Methods for Determining the Stability and Noise Performance of Modelocked Laser Pulses

The most important issue when designing a short-pulse laser system is usually to determine the adjustable parameter range in which that laser operates stably and to optimize the pulse parameters. Current design tools are inadequate for this task. We have been developing computational tools, based on spectral methods, that are both quantitatively accurate and can rapidly determine the laser's stability and noise performance. Here, we give a status report and discuss applications.

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MS30

Semiclassical Analysis of the Three-Wave Resonant Interaction Equations

The three-wave equations are a completely integrable multicomponent system exhibiting pumping, energy transfer, and other phenomena not seen in single-component systems. We consider the small-dispersion limit. WKB analysis is used to obtain a sequence of reflectionless initial conditions with a small dispersion limit. The inverse-scattering problem is solved explicitly for representative cases to illustrate a variety of phenomena in the time evolution, including the emergence of oscillatory regions from the collision of non-oscillatory packets.

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MS30

Propagation of Regularity for Solutions of the Generalized Korteweg-De Vries Equation

We will discuss special regularity properties of solutions to the IVP associated to the k-generalized KdV equations. In particular, for datum $u_0 \in H^{3/4+}(\mathbb{R})$ whose restriction belongs to $H^k((b,\infty))$ for some $k \in \mathbb{Z}^+$ and $b \in \mathbb{R}$ we prove that the restriction of the corresponding solution $u(\cdot,t)$ belongs to $H^k((\beta,\infty))$ for any $\beta \in \mathbb{R}$ and any $t \in (0,T)$. Thus, this type of regularity propagates with infinite speed to its left as time evolves.

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MS30

On the Inverse Scattering Problem of the Benjamin-Ono Equation

The Benjamin-Ono equation describes internal gravity waves in a two-layer fluid. It was discovered to be completely integrable by Nakamura, Bock and Kruskal. An inverse scattering transform scheme was described by Fokas and Ablowitz. Part of the scattering data depend on relations between different Jost solutions to a singular integral perturbation of the derivative operator. In this talk we prove the existence and uniqueness of these Jost solutions, together with some key identities useful for the inverse scattering transform scheme.

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MS31

Observation of Breather Solitons in Microresonators

We present the first observations of breather solitons in microresonators. We find that both silicon nitride and silicon microresonators exhibit narrow low-frequency RF modulation sidebands for a range of cavity detunings as we tune the pump frequency into the mode-locked regime. We identify these sidebands as a key signature of persistent breather solitons within the resonators. Our results provide a new perspective on the evolution towards stable soliton formation in microresonator frequency combs.

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MS31

Numerical Simulations of Kerr Frequency Combs Meet the Reality

Understanding of behavior of Kerr frequency combs generated in nonlinear optical ring resonators pumped with continuous wave light primarily relies on numerical simulations. We present several successful examples of usage of numerical modeling based on ordinary differential equations as well as Lugiato-Lefever equation to both predict and explain various regimes of the frequency combs observed in crystalline optical microresonators. We also discuss cases when numerical simulations and experimental studies have significantly different outcomes.

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MS31

Development of Ultra-High Resolution Supercontinuum Optical Sources Aided by High Performance Computing

In a recently started project we aim at developing a new generation of supercontinuum light sources with unprecedented low noise and shaped power spectra that are optimal for use in the next generation ultra-high resolution Optical Coherence Tomography (UHROCT) systems. Our goal is to use UHROCT for cost effective diagnose of glaucoma, the second leading cause of blindness worldwide, and to develop equipment easy to use for a local clinic contrary to current practice. The project is conducted in collaboration with NKT Photonics, designing supercontinuum and OCT systems, and Bispebjerg Hospital, Denmark. The main task is to design poly crystal fibers with tapering and other design features for reducing the noise in a supercontinnum light source and shape its spectrum. Here we focus on mathematical modeling and high performance computing for achieving the above goal. The modeling is based on a generalized nonlinear Schroedinger equation including higher order dispersion, delayed Raman response and tapering. The numerical model is based on state-of-the-art Spectral Methods and implemented using modern parallel programming paradigms such as MPI and OpenCL to run efficiently on modern and emerging parallel computing many-core hardware as graphical processing units. High performance computing has turned necessary in the study of super continuum generation mainly due to the complexity of the nonlinear wave (soliton) patterns requiring extremely high computational resolution.

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MS31

Propagation of Light in Non-Adiabatically Driven Optical Microresonator

An optical pulse propagating in a bottle microresonator (a dielectric cylinder with a nanoscale-high bump of the effective radius) can exactly imitate a quantum wave packet described by the one-dimensional Schrdinger equation with a potential (quantum well) proportional to the variation of the effective radius of the bottle. We investigate oscillations of an optical pulse in a quantum well perturbed by non-adiabatic time-dependent pulsed and periodic potentials.

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MS32

Point-Wise Stability of Reaction Diffusion Fronts

Using point-wise semigroup techniques, we establish sharp rates of decay in space and time of a perturbed reaction diffusion front to its time-asymptotic limit. This recovers results of Sattinger, Henry and others of time-exponential convergence in weighted L^p and Sobolev norms, while capturing the new feature of spatial diffusion at Gaussian rate. Novel features of the argument are a point-wise Green function decomposition reconciling spectral decomposition and short-time Nash-Aronson estimates and an instantaneous tracking scheme similar to that used in the study of stability of viscous shock waves.

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MS32

The Gray-Scott Model: Bistable Regime

Using singularly perturbed nature of the Gray-Scott model, we apply multi-scale analysis in a systematic way to show the existence and stability of a traveling front and a traveling pulse. While the traveling front is stable, the pulse is unstable.

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MS32

Validated Numerics and the Evans Function

The goal of validated numerics is to provide rigorous mathematical statements based on numerical floating point results. After introducing some basic ideas from the field of validated numerics we will discuss a validated numerical approach for the evaluation of the Evans function. We formulate a suitable zero finding problem whose roots provide control over the Jost solutions. Using numerical approximate solutions as input we produce rigorous spectral information. The approach is illustrated using model examples.

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MS33

Diffusive Molecular Dynamics and its Relationship to Stochastic Models of Diffusive Transport

Diffusive molecular dynamics (DMD) is a model that attempts to describe materials on an atomistic spatial scale, but a diffusive time scale. A Variational Gaussian approximation is used for the mechanical state of the system. The chemical state of the system is described by occupancy fractions of the atomic sites. The deterministic dynamics are designed so that an approximate free energy is monotonically decreasing and the total mass of each species is conserved.
DMD holds great promise for simulating phenomena such as solute segregation to a defect, but its dynamics have not yet been related to a more fundamental model. We consider a jump-diffusion process as an accelerated dynamics for molecular dynamics (MD), with species exchange for nearest neighbor sites coupled to overdamped Langevin dynamics for the atomic positions. In numerical simulations of phase segregation in one spatial dimension, we have observed qualitative agreement of coarsening dynamics for the jump-diffusion process and DMD.

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MS33

Chemical Mechanical Waves in Cells That Lead to Motility

Abstract not available.

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MS33

Higher Order Nonlocal Operators

This talk will discuss a fourth-order nonlocal operator as a natural generalization of the biharmonic operator used in thin-plate theory. The operator is nonlocal and connects with peridynamic theory. We will discuss the relation of this operator with the local biharmonic operator. Lastly, we will outline a proof which demonstrates that when the nonlocal interaction horizon goes to zero, solutions of the nonlocal problem converge strongly in L^2 to functions in $W^{1,2}$. For sufficiently regular domains we are able to identify the limits as weak solutions of the corresponding local elliptic boundary value problems.

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MS33

A Model of Dielectric Breakdown in Solids Using Non-Local Fracture

A numerical model of dielectric breakdown in solids is presented that couples electro-quasistatics, adiabatic thermal heating, and peridynamics, a nonlocal fracture model. Coupling of the various fields occurs through the Lorentz force, Joule heating, and thermal expansion. In addition, a nonlinear conductivity model is used that links high electric fields with conductivity. A standard, point-based discretization is used for the peridynamic equations and a finite difference method is used for the electro-quasistatic problem.

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MS34

Pulses with Oscillatory Tails and a Homoclinic Banana in the FitzHugh-Nagumo System

It is well known that the FitzHugh-Nagumo system exhibits stable, spatially monotone traveling pulses, as well as traveling pulses with oscillatory tails. We discuss analytical results regarding the existence and stability of such pulses using geometric blow-up techniques and singular perturbation theory, and we outline a mechanism that explains the transition from single to double pulses that was observed in earlier numerical studies.

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MS34

Towards Stability of Periodic Pulse Solutions in Singularly Perturbed Reaction-Diffusion Equations

To establish nonlinear diffusive stability, we approximate the spectrum of the linearization about the periodic pulse pattern. In the singular limit the spectral stability problem splits into simpler and explicit subproblems in accordance with the scale separation. This leads to sufficient bounds on the spectrum of the perturbed problem except for one spectral curve that shrinks to the origin in the singular limit. Using Lin's method we determine the fine structure of this spectral curve.

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MS34

Absolute Instability in a Chemotaxis Model

In the 1970's Keller and Segel introduced a class of models for bacterial chemotactic motion through a consumable substrate. In general these models exhibit travelling wave solutions. In this talk I will talk about the spectral stability of these types of travelling waves. In particular, I will discuss how the absolute spectrum plays a role in the stability analysis. This is joint work with P v Heijster and P Davis at QUT.

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MS34

The Entry-Exit Function and Geometric Singular Perturbation Theory

For small $\epsilon > 0$, the system $\dot{x} = \epsilon$, $\dot{z} = h(x,z)z$, with $h(x,0) < 0$ for $x < 0$ and $h(x,0) > 0$ for $x > 0$, admits solutions that approach the x-axis while $x < 0$ and are repelled from it when $x > 0$. The relation between the limiting attraction and repulsion points is given by the well-known entry-exit function. For $h(x,z)z$ replaced by $h(x,z)z^2$, we explain this phenomenon using geometric singular perturbation theory. The linear case can be reduced to the quadratic case, which is related to periodic traveling waves in a diffusive predator-prey model.

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MS35

Nondegeneracy of Antiperiodic Standing Waves for Fractional Nonlinear Schrödinger Equations

In the stability and blowup analyses for traveling and standing waves in nonlinear Hamiltonian dispersive equations, the nondegeneracy of the linearization about such waves is of paramount importance. That is, one must verify that the kernel of the second variation of the Hamiltonian is generated by the continuous symmetries of the PDE. The proof of this property can be far from trivial, especially when the dispersion admits a nonlocal description where shooting arguments, Sturm-Liouville theories, and other ODE methods may not be applicable. In this talk, we discuss the nondegeneracy of the linearization associated with antiperiodic constrained energy minimizers in a class of defocusing NLS equations having fractional dispersion. Key to our analysis is the development of ground state and oscillation theories for linear periodic Schrödinger operators with antiperiodic boundary conditions. The antiperiodic nature of the problem greatly complicates the analysis, as linear Schrödinger operators with periodic potentials need not have simple antiperiodic ground states even in the classical (local) case. As an application, we obtain the nonlinear (orbital) stability of antiperiodic standing waves with respect to antiperiodic perturbations.

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MS35

Stability of Multi-D Viscous Detonations in Reactive Navier Stokes

Abstract not available.

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MS35

Multidimensional Stability of Large-Amplitude Navier-Stokes Shocks

Extending results of Humpherys-Lyng-Zumbrun in the one-dimensional case, we use a combination of asymptotic ODE estimates and numerical Evans-function computations to examine the multidimensional stability of planar Navier–Stokes shocks across the full range of shock amplitudes, including the infinite-amplitude limit, for monatomic or diatomic ideal gas equations of state and viscosity and heat conduction coefficients in the physical ratios predicted by statistical mechanics, with Mach number $M > 1.035$. Our results indicate unconditional stability within the parameter range considered, in agreement with the results of Erpenbeck and Majda in the corresponding inviscid case. Notably, this study includes the first successful numerical Evans computation for multi-dimensional stability of a viscous shock wave.

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MS35

O(2) Hopf Bifurcation of Viscous Shock Waves in a Channel

Abstract

We study $O(2)$ transverse Hopf bifurcation, or “cellular instability’, of viscous shock waves in an infinite channel, with periodic boundary conditions, for a class of hyperbolic-parabolic systems including the equations of thermoviscoelasticity. Due to the refection symmetry property of our model, the underlying bifurcation is not of planar Hopf type, but, rather, a four-dimensional $O(2)$ Hopf bifurcation: roughly speaking, a “doubled’ Hopf bifurcation coupled by nonlinear terms. Since the linearized operator about the wave has no spectral gap, the standard center manifold theorems do not apply; indeed, existence of a center manifold is unclear. To prove the result, we use the Lyapunov–Schmidt reduction method applied to the time-T evolution map of the underlying perturbation equations, resulting in a 4-dimensional stationary bifurcation problem with $O(2)$ symmetry plus an additional “approximate S^1 symmetry’ induced by the underlying rotational linearized flow.

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MS36

Proof of the Coupled Mode Asymptotics for Wavepackets in the Periodic NLS

Wavepackets composed of two modulated carrier Bloch waves with opposite group velocities in the one dimensional Periodic Nonlinear Schroedinger Equation (PNLS) can be approximated by first order coupled mode equations (CMEs) for the two slowly varying envelopes. Under a periodic perturbation of an arbitrary periodic structure the CMEs typically allow families of localized solitary waves parametrized by velocity. This leads to approximate solitary waves in the PNLS. We discuss a rigorous justification of the approximation and provide several numerical tests.

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MS36

Numerical Computation of Nonsmooth Solutions of Wave Equations

Many nonlinear wave equations of physical origin are naturally written in second order form. The theory of weak solutions and their numerical approximation for these systems is not so well developed as the analogous theory for first order systems of conservation laws. Here we examine various discretizations of a scalar problem in $1 + 1$ dimensions which has been proposed as a model of nematic liquid crystals and which develops unbounded derivatives in finite time.

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MS36

Transverse Instability of Electron Plasma Waves

Study via Direct 2+2D Vlasov Simulations

Transverse instability could be viewed as initial stage of electron plasma waves (EPWs) filamentation. We performed direct 2+2D Vlasov-Poisson simulations of collisionless plasma to systematicly study the growth rates of oblique modes of finite-amplitude EPW depending on it's amplitude, wavenumber, angle of the oblique mode wavevector relative to the EPW's wavevector and the configuration of the trapped electrons in the EPW. Simulation results are compared to the theoretical predictions of simplified models.

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MS36

Mapping Properties of Normal Forms Transformations for Water Waves

We consider the equations of water waves in the framework of Hamiltonian systems, for which the Hamiltonian energy has a convergent Taylor expansion in canonical variables near the equilibrium solution. We give an analysis of the mapping properties of the third and fourth order canonical transformations to Birkhoff normal form in the case of spatially periodic data in dimension $n = 2$. This is a joint work with Walter Craig.

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MS37

Isospectral Flows for the Shock Clustering Problem

Years ago, Menon and Srinivasan studied scalar hyperbolic conservation laws with certain Markov initial conditions, and discovered a Lax equation for the evolution of the generator of $u(x, t)$ as a Feller process in x. Subsequently, Menon also gave the equation for the lower triangular generator when the process has zero drift and assumes only finitely many states. In this talk, we will discuss this equation and its extension to full $N \times N$ matrices.

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MS37

Long-Time Asymptotic Behavior of Solutions to the DNLS for Soliton-Free Initial Data

We compute large-time asymptotics for the solution to the DNLS equation. We exploit the celebrated Deift-Zhou method of nonlinear steepest descent, drawing upon the more recent work of Do. Our results apply to a class of soliton-free initial data contained in some weighted Sobolev space.

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MS37

Adaptive Methods for Derivative Nonlinear Schrodinger Equations

Numerical simulations of L^2 supercritical derivative nonlinear Schrödinger equations suggest the existence of finite time singularities. Thus far, the numerical studies have relied upon either integration of the original equation or the dynamic rescaling method. The first appraoch is limited because of the singularity, while the latter appraoch is limited by the hyperbolic character of the nonlinearity. Using locally adaptive meshing methods, we are able to overcome prior difficulties, integrating closer to the singularity time.

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MS37

Small Dispersion for the Benjamin-Ono Equation with Rational Initial Data

In this talk we rigorously analyze the scattering data of the Benjamin-Ono equation with a rational initial condition in the small-dispersion limit. We are able to derive formulas for the location and density of the eigenvalues, magnitude and phase of the reflection coefficient, and density of the phase constants. This procedure validates previous well-known formal results and provides new details concerning the leading order behavior of the scattering data.

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MS38

Stability of Short-Pulse Solutions of the Complex Cubic-Quintic Ginzburg-Landau Equation

We use the boundary-tracking algorithm to determine the precise parameter range in which stable pulse solutions of the complex cubic-quintic Ginzburg-Landau equation exist, and we discuss applications to short-pulse lasers. We explore the two-dimensional parameter space (cubic nonlinear gain) $\times$ (chromatic dispersion), and we compare our approach and results to earlier work by Akhmediev et al. that solved the evolution equations to determine the stability.

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MS38

The Lugiato-Lefever Equation and Cnoidal Waves in Microresonators

High-Q, externally pumped, microresonators with a Kerr nonlinearity can produce trains of mode-locked solitons that have important applications to metrology. Strictly speaking, however, solitons are solitary structures on an infinite line, while the train of pulses in a microresonator is necessarily periodic. Moreover, qualitatively different periodic structures, that have been referred to as Turing rolls, can appear in a microresonator. Thus, it is important to examine the impact that periodicity has on pulsed solutions in a microresonator. The generation of frequency combs in nonlinear microresonators is governed by the Lugiato-Lefever equation (LLE). We show that the family of periodic solutions of the LLE, that includes solitons and Turing rolls, can all be represented analytically as Jacobi elliptic functions when loss is neglected. These cnoidal-wave solutions come in two generic forms, corresponding to two different types of Jacobi elliptic functions [$\mathrm{dn}(x|k^2)$, $\mathrm{cn}(x|k^2)$], where k is the modulus of these functions. When loss is included, we find that these two basic solution types still exist. Like solitons, which correspond to $\mathrm{dn}(x|1)$ or $\mathrm{cn}(x|1)$, the cnoidal-wave solutions can no longer be represented analytically when loss is included, but they continue to exist. We also discuss the accessibility of these cnoidal waves in the realistic lossy case and their potential uses.

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MS38

Modeling Modelocked Fiber Lasers With Slow Saturable Absorbers

Robust and relatively low cost modelocked fiber lasers have been developed that use polarization-maintaining fibers and semiconductor saturable absorber mirrors (SESAMs). A SESAM opens up a gain window behind the optical pulse that leads to wake modes. We computationally study these modes. We show that these modes are the source of experimentally-observed sidebands and determine the limit that they impose on the laser's stability.

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MS38

Spectra of Short Pulse Solutions of the Cubic-Quintic Complex Ginzburg Landau Equation Near Zero Dispersion

We compute spectra and slowly-decaying eigenfunctions of linearizations of the cubic-quintic complex Ginzburg-Landau equation about numerically-determined stationary solutions. In the presence of large dissipative effects, the spectral structure is qualitatively different from that predicted by the small dissipation theory of Kapitula and Sandstede. In particular, in the normal dispersion regime there is a bifurcation in which a pair of real eigenvalues merges with the intersection point of the two branches of the continuous spectrum.

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MS39

Freezing Waves in Equivariant Hamiltonian PDEs

We consider the application of the freezing method to Hamiltonian PDEs that exhibit nonlinear wave solutions. By adding a phase condition, the original problem is transformed into a partial differential algebraic equation, for which relative equilibria become steady states. We prove their Lyapunov stability under the assumptions of the Grillakis-Shatah-Strauss theory. We also analyze the stability under numerical approximations, and apply the theory to the cubic nonlinear Schrödinger equation.

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MS39

Validated Computation of Local Stable/Unstable Manifolds and Applications

I will discuss some methods for validated computation of local stable/unstable manifolds for equilibria/periodic orbits of differential equations. By combining these methods with techniques for validated solution of two point boundary value problems it is possible to obtain computer assisted proofs for connecting orbits. Such proofs can be used in the study of nonlinear waves. This is a sequel to the talk of J.B. van den Berg.

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MS39

Solving Connecting Orbit Problems Using Validated Computational Methods

The past few decades have seen enormous advances in the development of computer assisted theorems and proofs in dynamical systems. In this talk we will review recent developments in the computer-assisted, mathematically rigorous study of heteroclinic and homoclinic orbit problems for ODEs. We will look at the general setup of the machinery, several examples from pattern formation, and limitations of the current methods.

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MS40

Cohesive Evolution with Nonconvex Potentials and Fracture

We formulate a nonlocal cohesive model of peridynamic type for calculating the deformation inside a cracking body. The force interaction is derived from a nonconvex strain energy density function, resulting in a nonmonotonic material model. The model has the capacity to simulate nucleation and growth of multiple, mutually interacting dynamic fractures. In the limit of zero region of integration, the model recovers a sharp interface evolution characterized by the classic Griffith free energy of brittle fracture with elastic deformation satisfying the linear elastic wave equation off the crack set.

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MS40

A Massively Parallel Scalable Implicit SPH Solver

The most commonly used Smoothed Particle Hydrodynamics (SPH) implementation for solving the compressible Navier-Stokes (NS) equations is the Weakly Compressible SPH (WCSPH) method. This conventional approach suffers from convergence issues resulting from the spatial discretization – running WCSPH at larger scales to refine the discretization does not improve the quality of the solution. Further, small timesteps may be required, as dictated by the CFL condition, requiting substantial computational expense. To address these issues, we utilize local correction tensors in the context of an implicit SPH method, providing second order convergence while allowing for much larger timesteps. We provide a scalable massively parallel implementation of the resulting Implicit Smoothed Particle Hydrodynamics (ISPH) method in the LAMMPS molecular dynamics code, utilizing Krylov solvers and algebraic multigrid preconditioners from the Trilinos library, and demonstrate the method on several problems of interest.

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MS40

On the Consistency Between Nearest-Neighbor Peridynamic Discretizations and Discretized Classical Elasticity Models

Peridynamics is a nonlocal reformulation of classical continuum mechanics. At the continuum level, it has been demonstrated that classical (local) continuum mechanics is a special case of peridynamics. Such a connection between these nonlocal and local theories has not been extensively explored at the discrete level. We investigate the consistency between nearest-neighbor discretizations of linear elastic peridynamic models and finite difference discretizations of the Navier-Cauchy equation of classical elasticity. We demonstrate that using the standard meshfree approach in peridynamics, nearest-neighbor discretizations do not reduce, in general, to discretizations of corresponding classical models. We study nodal-based quadratures for the discretization of peridynamic models, and we derive quadrature weights that result in the desired consistency. The quadrature weights that lead to such consistency are, however, model-/discretization-dependent. We motivate the choice of those quadrature weights through a quadratic approximation of displacement fields. The stability of nearest-neighbor peridynamic schemes is also demonstrated through a Fourier mode analysis. Finally, an approach based on a normalization of peridynamic constitutive constants at the discrete level is explored. This approach results in the desired consistency for one-dimensional models, but does not work in higher dimensions.

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MS40

Tunable Band-Gaps in Finitely Deformed Dielectric Elastomer Laminates

Dielectric elastomers (DEs) promise a rich band-gap structure. The motivation for using heterogeneous DEs stems from their ability to sustain large strains at the one hand and deform due to electric stimulation at the other. We examine modes of small electroelastic waves propagating on top of finitely deformed configurations. The analysis reveals how band gaps can be shifted and their width can be modified by properly adjusting the bias electrostatic load and pre-stretch.

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MS41

A Lyapunov Functional for the Hasimoto Filament

We investigate the nonlinear stability of the one-soliton solution of the Vortex Filament Equation (VFE) without making recourse to its well-known correspondence with the Nonlinear Schrödinger equation. After formulating the VFE as a Hamiltonian system that is invariant under a group of symmetries on a suitable space of curves, we propose a Lyapunov functional for the Hasimoto filament and discuss its orbital stability.

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MS41

Title Not Available

Abstract not available.

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MS41

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Abstract not available.

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MS41

An Effective Integration Method for Two-Phase Solutions of the Focusing NLS Equation

An effective integration method, based on the classical solution to the Jacobi inversion problem, is presented for quasi-periodic two-phase solutions of the focusing nonlinear Schrödinger equation. The two-phase solutions with real quasi-periods are known to form a two-dimensional torus, modulo a circle of complex phase factors, that can be expressed as a ratio of theta functions. In this paper, the loci of the Dirichlet eigenvalues of the two-phase solutions are explicitly parametrized in terms of the modulus and the wavenumber of the solution. Simple formulas are obtained, in terms of the imaginary parts of the branch points, for the maximum modulus and the minimum modulus of the two-phase solution.

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MS42

Interaction of Localized Structures for a Generalized Klausmeier Model

We study a generalization of the Klausmaier model which is used to describe the evolution of vegetation patterns. Our main goal is to examine the influence of the spatial variation of terrains. Along the construction of pulse solutions (representing vegetation patches) via an extension of geometric singular perturbation theory to non-autonomous systems, we examine the dynamics of N-pulses and wave trains to get further insight into the process of desertification. This is joint work with Arjen Doelman and Robbin Bastiaansen.

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MS42

Instabilities of Periodic Waves in Dispersive Systems

For a general class of reversible or Hamiltonian systems, we prove that periodic waves exist and are modulationally unstable. The key hypothesis is on the spectrum of the linearization at a trivial solution, for which we assume that it contains two pairs of non-resonant complex conjugated purely imaginary eigenvalues. We apply this result to a class of gravity-capillary periodic traveling water waves.

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MS42

Maslov Index and Applications: A Review

We will review recent results obtained by G. Cox, C. Jones, R. Marangell, A. Sukhtayev, S. Sukhtaiev and the speaker on connections between the Morse index (the number of unstable eigenvalues) and the Maslov index (the signed number of crossings of a path in the space of Lagrangian planes with the train of a given plane) for differential operators that appear when one linearizes nonlinear PDEs about traveling wave solutions

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MS42

Stability of Waves for the Short Pulse Equation

We construct various periodic traveling wave solutions of the Ostrovsky/Hunter- Saxton/short pulse equation and its KdV regularized version. For the regularized short pulse model with small Coriolis parameter, we describe a family of periodic travelling waves which are a perturbation of appropriate KdV solitary waves. We show that these waves are spectrally stable. For the short pulse model, we construct a family of travelling peakons with corner crests. We show that the peakons are spectrally stable as well.

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MS43

Modeling and Simulation of Two-Color Light Filament Dynamics

Light filamentation remains and important area in nonlinear optics with much ongoing theoretical and experimental research efforts. Modeling requires understanding of light matter interactions with a particular objective of determining conditions that produce robust long lived optical filaments. Under suitable conditions, resonance can lead to multicolored filaments. On this, we will present results that consider the co-existence of 2 color filaments in two scenarios: co-propagation of UV/IR filaments in the atmosphere and the combined filaments of a fundamental frequency and its second harmonic propagating in quadratic crystals.

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MS43

Coherent Structures in Exciton-Polariton Condensates

Abstract not available.

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MS43

Formation of Limiting Stokes Wave from Non-Limiting Stokes Wave: Merging of Square Root Branch Points from the Infinite Set of Sheets of Riemann Surface to Form 2/3 Singularity of Limiting Wave

Stokes wave is the fully nonlinear periodic gravity wave parameterized by its height. Wave of greatest height has the limiting form with 120 degrees angle on the crest. Assume $z(\zeta)$ provides a conformal map of a free fluid surface of Stokes wave into the real line with fluid domain mapped into the lower complex half-plane of ζ. Then Stokes wave is fully characterized by the complex singularities in the upper complex half-plane. The only singularity in the physical sheet of Riemann surface of non-limiting wave is the square-root branch point located at $\zeta = i\zeta_c$. Corresponding branch cut defines the second sheet of the Riemann surface if we cross the branch cut. We found the infinite number of square root singularities in infinite number of non-physical sheets of Riemann surface. These singularities located both symmetrically $\zeta = \pm i\zeta_c$ and on diagonals (with respect to vertical axis) corresponding to different non-physical sheets of Riemann surface. Increase of the height of the Stokes wave means that all these singularities simultaneously approach the real line from different sheets of Riemann surface and merge together forming 2/3 power law singularity of the limiting wave. It was conjectured (P.M. Lushnikov, ArXiv:1507.02784) that non-limiting Stokes wave $z(\zeta)$ at the leading order consists of the infinite product of nested square root singularities which form the infinite number of sheets of Riemann surface.

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MS43

Solitary Patterns of Progressive Water Waves

The dynamics of solitary wave packets and modulated trains is described within the frameworks of weakly nonlinear models for surface water waves, direct numerical simulations of the Euler equations and laboratory tests. Limits if steep waves and short modulations are most focused. The long-living coherent wave patterns change the appearance and statistics of the sea surface essentially. This knowledge may be used to develop methods for dangerous wave forecasting systems.

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MS44

Local Structure of Singular Profiles for a Derivative Nonlinear Schrodinger Equation

The Derivative Nonlinear Schrödinger equation is an L^2-critical dispersive model for Alfvén waves. Recent numerical studies on an L^2-supercritical extension of this equation provide evidence of finite time singularities. Near the singular point, the solution is described by a universal profile that solves a nonlinear elliptic eigenvalue problem, In the present work, we describe the deformation of the profile and its parameters near criticality, combining asymptotic analysis and numerical simulations.

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MS44

Asymptotic Stability for Scalar Field Kinks

In this talk we consider a classical equation known as the phi-four model in one space dimension. The kink is an explicit stationary solution of this model. From a result of Henry, Perez and Wreszinski it is known that the kink is orbitally stable with respect to small perturbations of the initial data in the energy space. In this talk we discuss asymptotic stability of the kink for odd perturbations in the energy space. The proof is based on Virial-type estimates partly inspired from previous works of Martel and Merle on asymptotic stability of solitons for the generalized Korteweg-de Vries equations. However, this approach has to be adapted to additional difficulties, pointed out by Soffer and Weinstein in the case of general Klein-Gordon equations with potential: the interactions of the so-called internal oscillation mode with the radiation, and the different rates of decay of these two components of the solution in large time.

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MS44

Averaging for Nonlinear Schrodinger Equations with Anisotropic Confinement

We consider nonlinear Schrdinger type equations in several spatial dimensions which are subject to external electromagnetic fields, furnishing a strong anisotropic confinement. By means of an averaging procedure, we will derive, and analyze, effective models governing the unconfined dynamics. This is joint work with Florian Mehats and Rupert Frank.

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MS45

A Dynamical Approach to Elliptic Equations on Bounded Domains

We describe a procedure for reducing an elliptic PDE on a bounded domain to an (infinite-dimensional) dynamical system on the boundary. Suppose $\Omega \subset R^d$ is a bounded domain and u solves a linear elliptic equation $-\Delta u + V(x)u = 0$ on Ω. When the domain is deformed through a one-parameter family $\{\Omega_t\}$, the Cauchy data of u on $\partial\Omega_t$ satisfies a Hamiltonian evolution equation. If Ω is deformed smoothly to a point, this equation admits an exponential dichotomy, with the unstable subspace at time t corresponding to the Cauchy data of weak H^1 solutions to the PDE on Ω_t. This generalizes existing work in spatial dynamics, for the case of an infinite cylindrical domain. (Joint work with Margaret Beck, Chris Jones, Yuri Latushkin and Alim Sukhtayev.)

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MS45

Hopf Bifurcation from Fronts in the Cahn-Hilliard Equation

We study Hopf bifurcation from traveling-front solutions in the Cahn-Hilliard equation. Models of this form have been used to study numerous physical phenomena, including pattern formation in chemical deposition and precipitation processes. Technically we contribute a simple and direct functional analytic method to study bifurcation in the presence of essential spectrum. Our approach uses exponential weights to recover Fredholm properties, spectral flow ideas to compute Fredholm indices, and mass conservation to account for negative index.

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MS45

Domain Formation and Interface Evolution in Amphiphilic Systems

Molecules possessing a special amphiphilic structure have a tendency to organize and evolve into complex assemblies forming biomembranes. The biomembranes consisting of multiple amphiphiles can also phase separate into lipid rafts, that are believed to be responsible for membrane trafficking and intracellular signaling. We discuss a family of higher order energy functionals modeling these processes and present interface stability and evolution results for the corresponding gradient flows.

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MS45

Linear and Orbital Stability of Solutions to the VFE and the VFE Hierarchy

By the term vortex filament, we mean a mass of whirling fluid or air (e.g. a whirlpool or whirlwind) concentrated along a slender tube. The most spectacular and well-known example of a vortex filament is a tornado. A waterspout and dust devil are other examples. In more technical applications, vortex filaments are seen and used in contexts such as superfluids and superconductivity. One system of equations used to describe the dynamics of vortex filaments is the Vortex Filament Equation (VFE). The VFE is a system giving the time evolution of the curve around which the vorticity is concentrated. In this talk, we develop a framework for studying the linear and orbital stability of VFE solutions, based on the correspondence between the VFE and the NLS provided by the Hasimoto map. This framework is applied to VFE solutions that take the form of soliton solutions or closed vortices. If time permits, we will also tackle the case of solutions to other members of the VFE hierarchy of integrable equations.

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MS46

Detecting Causality in Nonlinear Dynamical Systems

Granger causality (GC) analysis has been widely applied in neuroscience research to infer causal interactions. The original GC analysis is based on linear regression. Here we show that, for general nonlinear dynamical systems, GC analysis could yield all possible incorrect causal directions. We then introduce time-delayed mutual information analysis to detect causality in nonlinear systems. Finally, we apply this method to study the relation of interneurons to LFP oscillations in the hippocampus.

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MS46

Granger Causality Reconstruction of the Network Topology of Hodgkin-Huxley Neuronal Networks

Neuronal networks are generally nonlinear dynamics. Can the Granger causality (GC), which is a linear statistical method used to reveal causal dependents between variables, be used to reconstruct neuronal network connectivity? Our numerical simulation results show that GC can be successfully employed to reconstruct Hodgkin-Huxley neuronal networks. By exploiting the spiking structure as well as other distinct features of neuronal dynamics, we will explain the mechanism underlying the success of this reconstruction.

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MS46

A Mechanism Underlying the Validity of the Second-Order Maximum Entropy Principle in Neuronal Network Dynamics

It has been reported that by using observed firing rates and pairwise correlations, the second-order maximum entropy model can fit well the distribution of neuronal firing patterns in many neuronal networks. We address the issue of why the second-order maximum entropy model can successfully describe the distribution of neuronal firing patterns. We perform a perturbation analysis to explore a possible network state in which the second-order maximum entropy model can be a good effective description.

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MS46

Nonuniform Sampling Granger Causality Analysis and its Application to Neuronal Network Reconstruction

Since Granger causality analysis based on evenly sampled time series can be unreliable if the sampling rate is not sufficiently high, we introduce a nonuniform sampling GC analysis framework, which yields a reliable causal analysis even at a low mean sampling rate. We also discuss dynamics-specific spectrum processing that can further improve the accuracy of nonuniform sampling GC analysis. In addition, we demonstrate the efficiency of the nonuniform sampling GC in reconstructing neuronal network topology.

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MS47

Birkhoff Normal Form for Nonlinear Wave Equations

Wave equations can be considered as Hamiltonian PDEs, that is, partial differential equations that can be considered in the form of a Hamiltonian system. Many theorems on global existence of small amplitude solutions of nonlinear wave equations in $\mathbb{R}^n$ depend upon a competition between the time decay of solutions and the degree of the nonlinearity. Decay estimates are more effective when inessential nonlinear terms are able to be removed through a well-chosen transformation. In this talk, we construct Birkhoff normal forms transformations for the class of wave equations which are Hamiltonian PDEs and null forms, giving a new proof via canonical transformations of the global existence theorems for null form wave equations of S. Klainerman and J. Shatah in space dimensions $n \geq 3$. The critical case $n = 2$ is also under consideration. These results are work-in-progress with A. French and C.-R. Yang.

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MS47

The Kodama Normal Form of the Fermi Pasta Ulam Chain

It is well-known that the KdV equation arises as a modulation equation for waves of low amplitude in the famous FPU (Fermi Pasta Ulam) chain of interacting particles. I will present a way to derive it rigorously using a normal form method developed by Kodama. In particular, conditions will be derived for the asymptotic integrability of the FPU chain to high order. This is joint work with Antonio Ponno.

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MS47

Normal Forms and Modulation Equations

Modulation equations play an important role in the understanding of solutions of complicated systems of nonlinear PDEs. Equations like the KdV or NLS are similar to normal forms for ordinary differential equations in that they encapsulate the essential behavior of whole classes of phenomena. This talk will be an introduction to this mini-symposium, focussing on recent advances in the understanding the role of resonances and their effects on normal forms in an infinite dimensional setting.

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MS47

KdV Dynamics and Traveling Waves in Polyatomic FPU

Using homogenization theory, we can derive and justify a Korteweg-de Vries limit for a polyatomic Fermi-Pasta-Ulam lattice problem under the assumption that the material parameters vary periodically. While the KdV approximation predicts the existence of solutions which look like solitary waves for long times, it does not guarantee that such solutions remain coherent forever. We discuss recent results on the global in time existence of "generalized solitary waves" in diatomic FPU lattices.

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MS48

Jamming Anomaly in $\sqrt{\sqcup}$-Symmetric Optics and Bose-Einstein Condensates

We consider a $\mathcal{PT}$-symmetric structure consisting of an element with loss coupled to an element with gain. As the gain-loss coefficient is increased, the energy flux from the pumped element to its dissipative counterpart should normally grow. Using the Gross-Pitaevskii equation with a variety of $\mathcal{PT}$-symmetric potentials, we study an anomalous situation where the flux through the gain-loss interface decreases despite the growth of the gain-loss coefficient.

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MS48

Integrable PT Symmetric Models and their Applications

Abstract not available.

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MS48

Breathers and Shelf-Type Solutions in a Nonlocal Discrete NLS Equation

We study properties of some breather type solutions of a nonlocal discrete NLS equation modeling propagation in waveguide arrays built from a nematic liquid crystal substratum. The nonlocality leads to some new effects, such a internal modes in orbitally stable breathers, and nonmonotonic profiles in interfaces. We present some new theoretical results explaining some of these numerically observed features. We also discuss symmetry, monotonicity, and spectral properties of energy minimizers, and some spectral properties of shelf-type solutions.

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MS48

Unraveling the State-Space of the Nonlinear Nonlocal Schrödinger Equation: Quasiperiodic Oscillations and Homoclinic Orbits

We study complex solitary wave dynamics in the nonlocal NLS equation. Constructing low-dimensional visualizations of its state-space by projection on dynamically important states helps elucidate such dynamics. In particular, the shape transformations of a radial soliton to a quadrupole are identified with homoclinic connections of the radial soliton. In the neighborhood of these homoclinic orbits we observe quasiperiodic soliton oscillations. Applications to other high-dimensional dynamical systems are foreseen.

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MS49

Existence and Stability of Spatially Localized Planar Patterns

Motivated by numerical stability results on spatially localized patterns in spatially extended systems, we show how the stability of patterns that are formed of nonlocalized fronts can be understood from the spectra of the underlying fronts. We use extended Evans functions to understand the spectral properties of these patterns on the original unbounded domain and on large but bounded domains, and we compare our results to previous findings on resonance poles and edge bifurcations.

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MS49

Towards Metastability in the Burgers Equation with Periodic Boundary Conditions

Roughly speaking, metastable solutions are capture transient behavior which persists for long times. Recent work on Burgers equation on the real line and on Navier-Stokes equation with periodic boundary conditions have provided some insight into various mechanisms for metastability. In this talk we discuss a candidate metastable solution for the viscous Burgers equation with periodic boundary conditions. We construct the "frozen-time' spectrum for this solution using ideas from singular perturbation and Melnikov theory. Finally, we indicate future directions in which this spectrum can be used to understand metastability for the full PDE.

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MS49

Approximation of Similarity Solutions in Hyperbolic-Parabolic PDEs

In this talk we will review the method of freezing for relative equilibria and similarity solutions in evolution equations. The method leads to a system of partial differential algebraic equations (PDAE) whose steady states are the relative equilibria, we are interested in. Under suitable conditions, these steady states are asymptotically stable. We present an easy to implement method for this PDAE-system, that is based on an implicit-explicit approach for the time-discretization, and suitable methods for the hyperbolic and parabolic part separately. As an example we consider the approximation of similarity solutions for Burgers' equation and show that the method is also able to capture meta-stable behavior without difficulties.

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MS49

Modeling Stripe Formation on Zebrafish

Zebrafish (Danio rerio) is a small fish with distinctive black and yellow stripes that form due to the interaction of different pigment cells. Working closely with the biological data, we present an agent-based model for these stripes that accounts for the migration, differentiation, and death of three types of pigment cells. The development of both wild-type and mutated patterns will be discussed, as well as the non-local continuum limit associated with the model.

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MS50

Improved Compressive Sensing Signal Reconstruction via Localized Random Sampling

Compressive sensing (CS) demonstrates that by using uniformly-random sampling, rather than uniformly-spaced sampling, higher quality image reconstructions are often achievable. Considering that the structure of sampling protocols has such a profound impact on the quality of signal reconstructions, we formulate a new sampling scheme motivated by physiological receptive field structure, localized random sampling, which yields significantly improved CS reconstructions. We demonstrate further that these improvements hold in recovering inputs into networks with nonlinear dynamics.

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MS50

Random Schrodinger Equation: From Radiative Transport to Homogenization

Wave propagation in random media is complicated due to the existence of multiple scales, and it is important to derive macroscopic models in practice. On one hand, the kinetic models such as radiative transport equations are widely used to describe wave energy scatterings on large scales. On the other hand, the wave field may admit a deterministic macroscopic limit and we observe no scatterings – homogenization occurs. In this talk, I will try to explain the transition from one regime to the other by analyzing the Schrodinger equation with a random potential. I will also discuss how the correlation properties of the randomness affect the transition.

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MS50

Dynamics of Wavepackets in Spatially Inhomogeneous Crystals by Multi-Scale Analysis

We study the dynamics of wavepackets in crystals whose structure is spatially inhomogeneous. We make the assumption that inhomogeneities occur over a length scale which is long compared to the lattice period so that we may treat the two scales as approximately independent. We work mainly in the setting of Schrodinger's equation, where the crystal structure is modeled by a 'two-scale' potential which varies periodically on the 'fast' scale and smoothly on the 'slow' scale, but our methods can be applied also to Maxwell's equations where the crystal structure is modeled by a 'two-scale' matrix of constitutive relations. Phenomena which result from spatial variation of the crystal structure are: the anomalous velocity of wavepackets due to Berry curvature of the Bloch spectral band (responsible for the spin Hall effect of light), and Landau-Zener-type interband transitions, in the presence of spectral band crossings. This is joint work with Michael Weinstein and Jianfeng Lu.

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MS50

A New Discontinuous Galerkin Interface Condition for Wave Problems

In this talk, we present some new results for using Discontinuous Galerkin methods in wave propagation problems involving fluid-structure (FSI) interaction.

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MS51

A Boundary Value Algorithm for Computing the Evans Function

The Evans function is a powerful tool in the study of stability of traveling waves. Within the last decade, numerical computation of the Evans function has seen significant advances and application. Further development of computational methods is merited to more efficiently study larger systems. We describe a boundary value algorithm for computing the Evans function, provide error bounds of end state convergence, and demonstrate its efficiency.

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MS51

Stability of Wavefronts in a Diffusive Model for Porous Media Combustion

We study the stability of fronts in a reduction of a model of combustion in hydraulically resistant porous media. We first consider the model with the Lewis number chosen in a specific way and with initial conditions of a specific form. We then show that the stability results for that system extend to the fronts in the full system with the same Lewis number. The fronts are either absolutely unstable or convectively unstable.

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MS51

The Maslov and Morse Indices for Schrödinger Op-

erators on $\mathbb{R}$

Assuming a symmetric potential that approaches constant endstates with a sufficient asymptotic rate, we relate the Maslov and Morse indices for Schrödinger operators on $\mathbb{R}$. In particular, we show that with our choice of convention, the Morse index is precisely the negative of the Maslov index.

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MS51

The Effect of Impurities on Striped Phases

We study the effect of algebraically localized impurities on striped phases in one space-dimension. We therefore develop a functional-analytic framework which allows us to cast the perturbation problem as a regular Fredholm problem despite the presence of essential spectrum, caused by the soft translational mode. Our results establish the selection of jumps in wavenumber and phase, depending on the location of the impurity and the average wavenumber in the system. We also show that for select locations, the jump in the wavenumber vanishes.

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MS52

Structured Neural Network and Orientation Selectivity in Mouse V1

Despite of a lack of orientation map in mouse V1, many experiments have shown that there are strong connections that correlate with the similarity between neuron's receptive fields within excitatory populations. Here we use large-scale conductance-based LIF neuronal network simulation to capture essential findings of both single-neuron and populational properties concerning orientation selectivity and their contrast dependency. Finally we will discuss how these phenomena may arise with its underlying structured neuronal circuits.

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MS52

Algebraic-Topological Methods for Understanding Function in Neural Populations

In the study of biological neural systems, an increasingly common alternative to studying the behavior of individual neural units (neurons, brain regions, etc.) is to study *population coding*: how the entire observed population responds to particular stimuli or behaves in some "resting" state. Temporal binning or computing correlations between activity of individual units reduces such observations to combinatorial objects, which can then naturally be interpreted as filtered simplicial complexes. Here, we describe how such complexes can be used to recover signatures of structure (or lack thereof) in the information encoded by such populations, or to extract "functional assemblies" that arise in various system states, in a fashion which is robust to the types noise and nonlinear responses which are common in biological systems.

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MS52

Balanced State in Inhomogeneous Neuronal Networks

The balance between excitation and inhibition is crucial for neuronal computation. The Balanced state has been observed in many experiments. Theoretical studies have mainly focused on the analysis of homogeneous networks. However, neuronal networks in the brain are usually inhomogeneous. Here we show that the balanced state can exist even in inhomogeneous neuronal networks and embedded in the original network there is a homogeneous sub-network that underlies origin of the balanced state.

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MS52

Neocortical Pyramidal Cells Can Send Signals to Post-Synaptic Cells Without Firing

There is evidence that neocortical pyramidal cell axons may be coupled by gap junctions into an axonal plexus capable of generating very fast oscillations (VFOs, >80 Hz). However, it is unclear how coupled pyramidal cells control which spikes may invade their own axon and propagate to axon terminals. We determined that somatic voltage can gate spikes from gap junctions on the main axon but not collaterals, predicting VFOs during cell depolarization and after axonal sprouting.

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MS53

On an NLS Approximation for a Quasilinear Water Wave Model via a Modified Energy Method

We will consider a quasilinear water wave model. In order to justify an NLS approximation for this model we must reconcile a loss of regularity due to the quasilinearity of the problem. To do so we will construct an appropriate energy functional, modeled on those of Hunter, et al, and use the space-time methods of Germain-Masmoudi-Shatah to justify the approximation for long-time.

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MS53

Interaction of Modulated Water Waves

Starting from the Zakharov/Craig-Sulem formulation for the water waves problem of finite depth with and without surface tension in one or two horizontal dimensions, we are interested in the macroscopic manifestation of the interaction of different weakly amplitude-modulated plane waves of the linearized problem when amplitude, macroscopic space and macroscopic time have the same scaling coefficient. Apart from the formal derivation of the corresponding modulation equations, we present results concerning their justification in the case of gravity waves, which are based on recent work of Alvarez-Samaniego and Lannes on the long-time well-posedness of the water waves problem of finite depth.

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MS53

Normal Form Flows for Quasi-Linear PDE

Abstract not available.

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MS53

Space-Modulated Stability and Periodic Waves of Dispersive Equations

Recently, partly motivated by applications to surface waves, rapid progresses on the stability theory of periodic waves have been obtained. In particular, for parabolic systems — including those encoding the shallow water description of viscous roll-waves — an essentially complete theory is now available. We shall expound here some first contributions to a dispersive theory, still to come.

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MS54

Universal Nature of the Nonlinear Stage of Modulational Instability

First I will show how modulational instability (MI) manifests itself within the inverse scattering transform for the focusing nonlinear Schrodinger (NLS) equation. Then I will characterize the nonlinear stage of MI by computing the long-time asymptotics of solutions of the focusing NLS with initial conditions that are a small perturbation of a constant background. For long times, the xt-plane divides into three regions: a left far field and a right far field, in which the solution equals the boundary condition to leading order, and a central region in which the asymptotic behavior is described by a slowly modulated elliptic solution.

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MS54

Constant-Intensity Waves in in Non-Hermitian Photonic Structures

In the context of Parity-Time (PT) symmetric photonics, we study the existence and properties of a novel class of waves in a general type of inhomogeneous photonic structures. Such systems are non-hermitian (contain gain, loss) and support generalized plane waves that feature a constant-intensity profile (CI-waves) throughout all of space. We are going to present results on both propagation (coupled waveguides) and scattering geometries (optical cavities). Extensions to two-dimensional complex geometries are going to be presented along with the diffraction properties of spatially truncated CI-waves. Furthermore, we will examine how CI-waves can lead to perfect transmission through disordered media of complex refractive index. This is a joint work with A. Brandsttter, P. Ambichl, Z. H. Musslimani, D. N. Christodoulides, and S. Rotter

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MS54

Numerical Exploration of a Coupled Nonlinear Schroedinger Equation

The adjoint continuation method developed by Ambrose and Wilkening is a powerful new method for the computation of stationary, periodic and traveling wave solutions to nonlinear dispersive partial differential equations. We use this method here to explore novel solutions of the parametrically forced nonlinear Schroedinger equation coupled to a heat equation, solutions whose dynamics can also be understood through finite-dimensional reductions.

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MS54

Solvability of the Cauchy Problem for the Derivative NLS by Inverse Scattering Theory

Our talk concerns with inverse scattering theory and its use to prove well-posedness of the Cauchy problem for the derivative NLS. We first show that the inverse scattering transform for the non-soliton case is a continuous bijective

map between appropriate function spaces. We extend this result for the N-soliton case by the Darboux transform, which can be used as a bridge between a pure dispersive solution and a N-soliton solution. The Cauchy problem for the derivative NLS equation with a *large* initial data has been an open problem. We solve this problem by integrable systems' tools. We conclude the talk by discussing the next steps. This is a joint work with Dmitry Pelinovsky.

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MS55

Wavetrain Solutions of a Reaction-Diffusion-Advection Model of Mussel-Algae Interaction

We consider a system of coupled partial differential equations modeling the interaction of mussels and algae in advective environments. A key parameter is the relative rate of advection of the algae concentration and diffusion of the mussel species. When advection dominates diffusion, one observes large-amplitude solutions representing bands of mussels propagating slowly in the upstream direction. We prove the existence of a family of such periodic wavetrain solutions using techniques from Geometric Singular Perturbation Theory.

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MS55

From Vortex Lines and Rings to Solitonic Shells, Hopfions and Beyond

In the present work, motivated by a series of recent experiments on vortices in quasi-2d atomic Bose-Einstein condensates and vortex rings and lines in 3d such condensates, we will explore their dynamics. We will start from the simpler example of the vortices and generalize to the vortex lines and rings. We will see (through degenerate perturbation theory) how such structures bifurcate from the linear limit of the problem. On the other analytically tractable (so-called Thomas-Fermi) limit, we will use a particle approach in order to characterize these coherent structures as particles. Between the two limits we will numerically interpolate, as well as attempt to characterize the spectral stability of the states. This analysis will provide insights on the potential observability of different structures in current state-of-the-art atomic experiments.

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MS55

Defects in the Swift-Hohenberg Equation

I will discuss static and dynamic properties of grain boundaries in pattern-forming systems, using the Swift-Hohenberg equation as a canonical model. In particular, I will focus on the transition between grain boundaries, pairs of concave-convex disclinations, and dislocations. I will present a mix of numerical simulations and analytical results. Some of this work is joint with N. Ercolani and N. Kamburov (University of Arizona).

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MS55

Growth and Patterns

We present results on pattern selection in growing domains. Depending on the rate of growth, we describe the growth process in terms of coherent structures. For slow growth, we isolate strain-displacement relations as the crucial ingredient. For moderate speeds of growth, invasion fronts and their interaction with boundaries determine selected patterns. For large speeds, we also give expansions for certain carefully chosen boundary conditions that allow the pattern-forming process not to detach from the boundary.

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PP1

Silnikov Chaos in SQUIDs

An rf superconducting quantum interference device (SQUID) consists of a superconducting ring interrupted by a Josephson junction (JJ). When driven by an alternating magnetic field, the induced supercurrents around the ring are determined by the JJ through the celebrated Josephson relations. This system exhibits rich nonlinear behavior, including chaotic effects. We study the dynamics of a pair of parametrically-driven coupled SQUIDs arranged in series. We take advantage of the weak damping that characterizes these systems to perform a multiple-scales analysis and obtain amplitude equations, describing the slow dynamics of the system. This picture allows us to expose the existence of homoclinic orbits in the dynamics of the integrable part of the slow equations of motion. Using high-dimensional Melnikov theory, we are able to obtain explicit parameter values for which these orbits persist in the full system, consisting of both Hamiltonian and non-Hamiltonian perturbations, to form so called Silnikov orbits, indicating a loss of integrability and the existence of chaos.

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PP1

A Numerical Continuation Approach for Water Waves of Large Amplitude

We study the flow beneath steady rotational periodic water waves in 2-D with general vorticity in the absence of stagnation points. The presented algorithm is a numerical continuation method using a predictor corrector scheme and utilizes analytic expansions to bifurcate from the branch of laminar waves. Numerical examples for different cases of vorticity illustrate the performance of the algorithm, wave characteristics and limitations for flows that are close to stagnation.

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PP1

Inverse Source Problem for the Damped Wave Equation: Application to the Hemodynamic Traveling Waves in Human Visual Cortex

Estimation of distributed cerebral blood flow using a damped wave equation is considered. This estimation can give a deep insight into the underlying dynamics of brain activation and the relationships between activated areas. It is also a crucial step in detecting and diagnosing neurological disorders. An efficient identification method based on modulating functions is proposed. The method has several advantages in term of accuracy, robustness against corrupting noise, and computational cost.

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PP1

Modeling of Topographic Rogue Wave Formation

In this work, a framework which relates strong depth transitions and non-equilibrium dynamics to rogue wave formation is developed from a theoretical and experimental standpoint. Nonlinear models are used to analyze the underlying relation between statistical properties of the water surface and wave physics concerning topographic variations. In addition to numerical simulation, the verification of the models is sought in a real wave tank using a digital video based measurement technique that captures local surface dynamics.

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PP1

Modeling of mRNA Localization in Xenopus Oocytes

mRNA localization is essential for Xenopus oocyte development and embryo patterning. This accumulation of RNA at the cell periphery is not well understood, but is thought to depend on diffusion, bidirectional movement and anchoring mechanisms. Our goal is to test these proposed mechanisms using PDE models and dynamical systems analysis, informed by numerical parameter estimation. Our results yield approximate traveling wave solutions and different parameter estimates in various regions of the cell cytoplasm.

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PP1

Three Layered Flows and the Non-Boussinesq Case

In this work, we will study a variety of configurations and limits of the equations for long waves in three-layered stratified flows. We will present results on the transition between hyperbolic (wave-like) and elliptic (unstable) behaviour, on the limiting rigid lid and Boussinesq cases, on the conserved quantities, together with numerical investigations of the dynamics.

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PP1

Stability of a Gap Soliton in the Present of a Weak Nonlocality in Periodic Potentials

We studied the stability and internal modes of one-dimensional gap soliton employing the modified NLS with a sinusoidal potential together with the present of a weak nonlocality. Using an analytical theory , it is proved that two soliton families bifurcate out from every Bloch-band edge under self-focusing or self-defocusing nonlinearity, and one of these is always unstable. Also we study the oscillatory instabilities and internal modes of the modified NLS.

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PP1

Optimizing Non-Linear Traffic Flow via Moving

Bottlenecks

We show that in certain situations it can be beneficial for the overall traffic flow if a vehicle on the highway drives slower than the rest, and thus serves as a moving bottleneck. This possibility arises with autonomous vehicles (AVs) that will enter our roads in a few years. Via vehicle-to-vehicle communication, AVs will possess non-local information, and they can execute driving protocols very accurately. One important practical application in which the local slowdown of traffic may be desirable is when a fixed bottleneck (e.g., an accident) has occurred further downstream. We derive various optimization criteria under which the described course of action makes sense, and calculate the optimal AV speed.

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PP1

Operator Splitting Methods for Maxwell's Equations in Ferromagnetic Materials

We present operator splitting methods for the 3D Maxwell's equations in a ferromagnetic material in which the magnetization is modeled using the Landau Lifschitz Gilbert (LLG) model from micromagnetism. We present an analysis of our splitting methods for the Maxwell-LLG system and results of numerical simulations that illustrate the theoretical results.

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PP1

Sparse Methods for PDE

We construct computational solvers for nonlinear PDE using sparse models. The sparse models enforce certain structural properties desired in either the numerical approximations and/or for computational efficiency. In some cases, we are able to show that the approximate models are exact. Applications include nonlinear elliptic equations, conservation laws, and free boundaries.

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PP1

Higher Order Accurate Hybrid-Weno Scheme for Modified Burgers' Equation

We study the modified Burgers equation

$$u_t + (u^m)_x = \epsilon u_{xx}, \tag{2}$$

where m is any positive integer. It is well known that high order finite difference schemes produce oscillations for small value of ϵ. We propose a higher order accurate hybrid-WENO scheme, which produces non-oscillatory solution. The Numerical scheme involves fifth order WENO scheme in the high gradient regions, and a higher order finite difference scheme is used in rest of the part. Several numerical experiments are performed to validate the proposed scheme.

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PP1

Dispersive Hydrodynamics Near Zero Dispersion

In general dispersive Eulerian systems, choices of parameters can result in an inflection point in the dispersion relation, referred to as a point of zero dispersion. We investigate the Kawahara equation, which is the Korteweg-de Vries equation with a fifth order derivative term, as a universal asymptotic approximation. The Kawahara equation exhibits one free parameter yielding either concave dispersion or a zero dispersion point. A particular problem of interest to these types of equations is step initial data, or the Riemann problem. Utilizing a careful numerical analysis and asymptotic calculations, we investigate the Riemann problem for the Kawahara equation. Depending on the curvature of dispersion, two distinct structures evolve form the initial data. In the case of strictly negative dispersion, the discontinuity in the Riemann problem is resolved via a dispersive shock wave (DSW) with a leading soliton edge that is connected to small amplitude linear waves via a modulated, nonlinear wavetrain. In the case of a non-convex dispersion, the discontinuity results in a DSW for sufficiently small jump whereas, for sufficiently large jumps, the discontinuity is resolved by a soliton–with speed well described by the Rankine-Hugoniot condition–that is adjacent to a resonant linear wavetrain propagating at the same speed. Due to the applicability of the Kawahara equation to general dispersive Eulerian media, this resonant phenomenon appears to be quite ubiquitous.

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PP1

The Four Wave Interaction System Makes Wrong Predictions for Systems with Unstable Quadratic Resonances

When several dominant wave-modes are present, their mutual interaction is significant. This is specially so when some of these modes resonate. Systems for the (resonant) four wave interaction (FWI) can be derived via multiple scaling analysis for the approximate description of the interaction of N modulated wave packets in a number of physical situations. They are also used as a model, for the description of gravity driven surface water waves and in the description of so called freak waves in deep sea. We aim to show that the (resonant) FWI system makes wrong predictions on the natural time scale of the approximation if unstable quadratic resonances are present in the original system.

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