IP1

Novel Electro-magnetic Phenomena: One-way-waveguides and Wireless Power Transfer

We describe two unusual mechanisms for the transport of electromagnetic energy: ONE-WAY WAVEGUIDES: An ordinary waveguide transports waves going both forwards and backwards. A one-way waveguide supports only waves propagating in a single direction. Obstacles and disorder can no longer reflect waves, which exhibit 100% transmission even across seemingly impassible perfectly-conducting barriers. We explain how such phenomena, analogous to quantum-Hall edge states, can arise from gyromagnetic materials, and present our experimental demonstration. NONRADIATIVE WIRELESS POWER TRANSFER: We describe our work on a technique for wireless power transfer using strongly-coupled long-lived electro-magnetic resonances. Instead of irradiating the environment with electromagnetic waves, the source fills the space around it with a “non-radiative' near-field. This technique could potentially be used for middle-range power transfer, such as within a room, or a factory pavilion.

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IP2

Spin Torque with Point Contacts: Generating Nonlinear Waves with Magnetic Media in a Localized Way

Spin torque offers new means to locally excite nonlinear dynamics in magnets. Possible applications include oscillators, disk drive heads, and non-volatile memory. Theoretical analysis is made challenging by the inherent difficulties of stiff differential equations with non-local terms. Originally formulated in 1999, analysis of the nonlinear Landau-Lifshitz-Slonczewski equation has proceeded either by perturbative amplitude expansion or brute force micromagnetic simulations. I will survey the current state-of-the-art, with and emphasis on efforts to accelerate simulation algorithms for infinite domains, and analysis of a novel magnetic excitation: the magnon 'droplet.'

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IP3

Interaction Between Internal and Surface Waves in a Two Layers Fluid

We consider a situation in which a fluid is composed of two essentially immiscible layers separated by a sharp interface such as a thermocline or a pycnocline of differential salinity. Internal waves of various types are commonly generated in the worlds oceans, and large amplitude, long wavelength nonlinear waves can be produced in the interface and propagate over large distances. In some physically realistic instances, the visible signature of internal waves on the surface of the ocean is a band of roughness which propagates at the same velocity as the internal wave. Several of the earliest observations are the most striking, consisting of long brightly shining strips of many kilometers in extent, visible through the effect of the reflection at an oblique angle of the setting sun, and photographed from the Space Shuttle. I will discuss the asymptotic analysis of the coupling between the interface and the free surface of a two layers fluid in a scaling regime chosen to capture these observations, in which the internal mode is treated as a long wavelength nonlinear internal wave, while the surface mode is smaller and taken in a modulational regime. This talk is based on joint work with Walter Craig and Philippe Guyenne.

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IP4

Extreme Elastohydrodynamics

The borderlands between elasticity and hydrodynamics lead naturally to a number of moving boundary problems in elastohydrodynamics. I will discuss some phenomena in this rich area involving extreme geometries using a combination of experimental, analytical and numerical approaches: the flapping of a slender flag in a breeze and its generalizations, the generation and propagation of elastohydrodynamic solitary waves, the dynamics of gait and speed selection in fish swimming far from and close to a wall, and the mechanics and control of song production in birds.

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IP5

Coherent Dynamics in Large-scale Cortical Networks

Spatially structured oscillations and waves arise both in vivo and in vitro, and may be observed experimentally using multi-electrode arrays or voltage-sensitive dye optical imaging. Such organizing activity in the brain has been purported to play a role in sensory perception, the execution of motor commands, working memory, early cortical development and certain brain pathologies such as epilepsy. In this talk we describe various forms of coherent brain dynamics including travelling pulses, spiral waves, spatially periodic patterns, and neuronal avalanches. We then show how to analyze such phenomena using population-based continuum neural field theories.

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IP6

Numerical Relativity: An Overview of the Field and Some Recent Results in Black Hole Simulations

In this talk I will give a review of the field of numerical relativity. I will discuss the 3+1 split of spacetime and the basic equations that need to be solved. I will briefly discuss the problem of finding initial data and of choosing appropriate coordinate (gauge) conditions, concentrating particularly in the case of black hole spacetimes. I will also briefly discuss the recent spectacular breakthroughs in the simulation of binary black hole systems, and some of the more interesting and exciting physical results that have been obtained from those simulations.

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IP7

Lax Equations and Kinetic Theory for Shock Clustering and Burgers Turbulence

Much of our current understanding of statistical theories of turbulence relies on vastly simplified caricatures. One such caricature is Burgers turbulence. This is the study of the statistics of shocks in Burgers equation with random initial data or forcing. This model also arises in statistics, combinatorics, and models of coagulation and surface growth. It is of wide interest as a benchmark, even if it describes phenomena that are not entirely turbulent. I will describe a kinetic theory for shock clustering that applies to all scalar conservation laws with convex flux and a basic class of random initial data. A remarkable feature of the kinetic theory is that it is presented as a Lax pair, admits remarkable exact solutions, and seems to have deep connections with completely integrable systems. The talk relies heavily on joint work with Bob Pego and Ravi Srinivasan.

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CP1

Three-Dimensional Vortex Soliton Interaction in Waveguide Arrays

Three-dimensional vortex propagation in two-dimensional arrays of optical waveguides presenting dispersion, nonlinearity and discrete diffraction, is investigated by means of both variational analysis and numerics. Several structures with vorticity S=1 or 2 are studied, among which some vortices with S=1 are stable. Interactions are numerically investigated, four typical outcomes are identified, depending on the initial relative velocity: rebound of slow solitons, fusion, splitting, and quasielastic interactions of fast solitons.

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CP1

Collocation Fourier Methods for Bose-Einsterin Condensates

There seems to exist few reports for non-periodical solutions by spectral Fourier methods under the Dirichlet conditions. In this paper, we will explore the spectral Fourier method(SFM) and the collocation Fourier methods(CFM) for linear and nonlinear elliptic and eigenvalue problems, and new error bounds are derived. Furthermore, the CFM is applied to Bose-Einstein condensates(BEC), and numerical results are coincident with the theoretical analysis.

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CP1

A Surface Tracking Algorithm for Fast Computation of Lagrangian Coherent Structures in 3D

Lagrangian Coherent Structures (LCS) have recently emerged as a powerful tool for analysing transport and mixing in fluid flows with arbitrary time dependence. However, the large computational time required to compute LCS remains a major hurdle. In this talk, we outline a surface tracking algorithm for LCS extraction. By performing calculations only near the LCS surfaces (instead of over the entire flow domain) large speed ups are achieved.

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CP1

Bifurcation Analysis of a Coupled Landau-Lifshitz-Slonczewski Equations

We consider a system of two Landau-Lifshitz equations with spin-transfer (Slonczewski) terms that model dynamics of two macrospins in a spin-torque device. Uniaxial symmetry conditions are assumed. We perform stability analysis based on reduction of this system of four ODEs to just one complex equation that can be solved explicitly. This allows to avoid a formidable task of finding eigenvalues of four-dimensional matrix with six parameters. Analytic conditions of stability are obtained and the bifurcation diagram is constructed. To find periodic solutions, another reduction of the original system is derived. Fixed points of this reduced system determine circular periodic orbits with phase locking.

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CP1

A Class of Vortex Filament Solitons in Fluids, Plasmas and Superconductors

We consider the Uby-Isichenko-Yankov equation (UIY) for vortex filament dynamics in plasmas and superconductors. This is a perturbation of the Localized Induction Equation (LIE), which is itself an integrable model of filament motion in an ideal fluid.We present a novel class of solutions for a time-modulated modification of UIY; namely, vortex configurations which are evolving spherical curves of varying radius. These solutions can be considered as generalizations of a well-known class of soliton solutions

for LIE.

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CP1
A Reaction-Diffusion Model of Persistent Bacterial Infection

Persisters are phenotypic bacterial variants which exhibit "antibiotic tolerance": they survive when exposed to bactericidal antibiotics, but the bacterial colonies regrown from persister cells remain susceptible to further antibiotic treatment. Exactly how bacteria switch into a persister state is unknown, but persister formation is linked to quorum sensing (the ability of bacteria to detect the local population density). Persisters are also implicated in the formation and maintenance of biofilms, and they are believed to play an important role in chronic bacterial infections that resist antibiotic treatment. Extending a prior model, we present a reaction-diffusion PDE model of bacterial growth which incorporates nutrient- and population-density dependent mechanisms of persister formation. The functional form of this dependence is chosen to match experimentally observed relationships between nutrient availability, population growth rates, and incidence of persister phenotypes. These relationships involve a separation of temporal and spatial scales in the formation of persister vs. regular bacteria. We investigate the pattern formation properties of the model as a number of experimentally accesible parameters are varied.

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CP2
Existence and Stability Analysis of $0-\pi-0$ Finite Josephson Junctions

We investigate analytically and numerically a Josephson junction on finite domain with two π- discontinuity points characterized by a jump of π in the phase difference of the junction, i.e. a $0-\pi-0$ Josephson junction. The system is described by a modified sine-Gordon equation. We show that there is an instability region in which semifluxons will be spontaneously generated. Using a Hamiltonian energy characterization, it is shown how the existence of static semifluxons depends on the length of the junction, the facet length, and the applied bias current. The critical eigenvalue of the semifluxons is discussed as well. Numerical simulations are presented, accompanying our analytical results.

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CP2
Exact Hamiltonian Equations for Fluid Films

Two dimensional models for hydrodynamic systems, such as soap films, have been studied for hundreds of years. Yet there has not existed a fully nonlinear system of dynamic equations analogous to the classical Euler equations. We propose an exact nonlinear system for the dynamics of a fluid film. The system is derived in the classical Hamiltonian framework and neither the velocities nor the deviation from the equilibrium are assumed small. We discuss the properties of the proposed equations and results of numerical simulations.

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CP2
Extracting Solitons from Perturbed and Noisy Signals

When studying optical solitons in the presence of perturbations, it is often required to extract the underlying soliton from a perturbed signal. We propose an iterative method for doing this, and show it converges for sufficiently small perturbations. In addition, we show the specific perturbations that most easily cause divergence of the iteration. We also present examples showing improved agreement (in comparison with more commonly used methods) between results from soliton perturbation theory and numerical simulations.

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CP2
Bifurcation Analysis of a Model in Population Dynamics

Bifurcation analysis of a model in population dynamics with explicit construction of the Poincare map. We perform bifurcation analysis of a logistic model with periodic harvesting using transformation of the model to Mathieu equation. This transformation allows to explicitly find the Poincare map, which is a very rare case for nontrivial models. We construct a bifurcation diagram in the two-dimensional parameter space showing regions with two and zero periodic solutions separated by transition curves where only one periodic solution exists. Stability of the periodic solutions is also determined. Using the same ideas, more general and realistic model with periodic coefficients can be analyzed. For this model, the same transformations lead to Hill's equation that can be solved approximately using Hill's determinant.

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CP2

Dynamical System Analysis of a Transmission Line Connected to Nonlinear Circuits

In a transmission line oscillator a linear wave travels along a piece of cable, the transmission line, and interacts with terminating electrical components. Diodes are integrated into almost all electronic devices as a means of protecting the logic circuits from destructive outside signals and high-voltage discharges. In the simple network model that we will present, we show nonlinear and chaotic effects associated with diodes that if transmitted into the primary circuitry will disrupt or possibly damage the device.

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CP3

Generalization of the Double Reduction Theory

In a recent work [1, 2] Sjoberg remarked that generalization of the double reduction theory to partial differential equations of higher dimensions is still an open problem. In this note we have attempted to provide this generalization to find invariant solution for a non linear system of qth order partial differential equations with n independent and m dependent variables provided that the non linear system of partial differential equations admits a nontrivial conserved form which has at least one associated symmetry in every reduction. In order to give an application of the procedure we apply it to the nonlinear (2 + 1) wave equation for arbitrary function f (u) and g(u).

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CP3

Internal Solitary Waves with a Weakly Stratified Critical Layer

This study considers the evolution of long internal waves. The weak amplitude assumption breaks down due to the presence of a critical layer at a certain height which strongly modifies the flow. Nonlinear effects are invoked to resolve this singularity. This theory is relevant for the phenomenon of internal-wave breaking and eventual saturation. Spatially localized solutions are described by an integrable modified Korteweg-de-Vries equation which supports a family of solitary waves.

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CP3

Gasdynamic Aspects of the Analytical Passage from Isentropic to Anisentropic: Contrasts, Consonances, and Classifying Remarks

Two genuinely nonlinear approaches [isentropic (of a Burnat type), respectively anisentropic (of a *minimal* Martin type) are associated each with a pair of regular classes of solutions [waves, wave-wave interactions]. We use two concurrent parallels [isentropic-anisentropic, respectively anisentropic-anisentropic (for two distinct anisentropic constructions)] to describe, by identifying some significant highly nontrivial contrasts and consonances, the *fragility* of the analytical passage, on the mentioned pairs of classes, from an isentropic context to an anisentropic context.

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CP3

Instability of the Split-Step Fourier Method on the Background of a Solitary Wave

We analyze a numerical instability that occurs in the split-step method on the background of a soliton. This instability is very sensitive to small changes of parameters of both the numerical grid and the soliton, unlike the instability of most finite-difference schemes. Moreover, the principle of "frozen coefficients", in which variable coefficients are treated as "locally constant", is strongly violated for this instability. (That is, the instability on the background of a plane wave having the same amplitude as the soliton, would be drastically different.) Our analysis is enabled by the fact that the period of oscillations of unstable Fourier modes is much smaller than the width of the soliton.

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CP3

High-Order Discontinuous Galerkin Schemes for 2+2 Vlasov Models on Unstructured Grids

The purpose of this work is to explore mesh-based alternatives to the Particle-In-Cell (PIC) methods that are currently favored in many plasma physics applications. In particular, we present here a technique for solving the Vlasov-Poisson system that is based on operator splitting in time and high-order discontinuous Galerkin discretiza-

tions in space. The efficiency of the method is increased by considering semi-Lagrangian approaches for the advection in phase space. The flexibility of the approach is enhanced by allowing the mesh in physical space to be unstructured.

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CP4

Nonlinear Waves Interaction and Defects Dynamics in Complex (dusty) Plasmas

Complex plasmas are suspensions of micro-particles in plasmas. They can be solid, liquid, or gaseous and exhibit dynamic effects. The micro-particles can be traced individually yielding full kinetic information about the system. Thus complex plasmas can be used as experimental model systems of solids and liquids to understand fundamental properties of matter. Here we report an experimental and numerical study of soliton interaction and steepening, shock wave propagation, and defect dynamics in monolayer lattices.

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CP4

Investigation of Rarefaction Waves in Discrete Materials with a Strain-Softening Behavior

We investigate the stationary propagation of rarefaction waves in a discrete system with an abnormal (softening) interaction force that supports rarefaction waves as stationary disturbances in nondissipative chains. However, stationary compression shock or solitary waves are not supported. Experimental observations of rarefaction waves in one-dimensional systems composed of steel cylinders and layers of strongly nonlinear materials with abnormal behavior are compared to theoretical and numerical analysis of stationary solutions for rarefaction shock and solitary waves.

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CP4

Internal Waves and Wave Turbulence

In this talk I will explain how one can use wave turbulence to attempt to explain the spectral energy density of internal waves in the ocean. I will explain basics of wave turbulence and explain how to use it oceanographic internal waves. I will demonstrate that using traditional formulation of wave turbulence one runs to internal logical contradictions. Namely the results of the theory (strong nonlinearity) contradict the underlying assumptions (weak nonlinearity) used to build the theory. I will demonstrate possible directions out of the puzzle and will elaborate on open questions and challenges.

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CP4

Kolmogorov-Like Cascades of Displayed and Hidden Perturbations of the Couette Flow

The Kolmogorov-like cascades of velocity and shear produced by displayed and hidden perturbations of the Couette flow are treated by the multiscale n-section method for resolving fluid-dynamic clusters of zeros and extrema. The cascades are computed by a new approach of numerical computing of high-order derivatives of generating functions with an arbitrary precision, which is adapted for trigonometric and hyperbolic invariant differential structures.

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CP5

Soliton Reflection in the Defocusing Nonlinear Schroedinger Equation with Non-Zero Boundary Conditions

We discuss boundary value problems (BVPs) for the defocusing nonlinear Schroedinger equation with non-zero boundary conditions (BCs) at infinity and linearizable BCs at the origin. We show that, unlike the initial-value problem, in these BVPs discrete eigenvalues appear in symmetric pairs, and we derive the corresponding symmetries for the norming constants. The apparent reflection experienced the solitons is due to the presence of a "mirror' soliton located beyond the edge of the spatial domain.

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CP5

Steady Flow of a Falling Jet Hitting a Horizontal Wall

We consider a steady two-dimensional jet falling from a vertical pipe. Depending on the elevation of the pipe relative to an infinite horizontal wall and the Froude number,

we study flows with or without stagnation points. The problem is reformulated using conformal mappings and is solved by a collocation Galerkin method. A particular form is assumed for the solution satisfying Bernoullis equation at certain discrete points. The resulting equations are solved by Newtons method.

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CP5

Random Attractors for Stochastic Sine-Gordon Lattice Systems

The Sine-Gordon equation is a nonlinear hyperbolic differential equation which has a wide range of applications in physics. We study the asymptotic behavior of solutions to the stochastic sine-Gordon lattice equations with multiplicative white noise. We firrst prove the existence and uniqueness of solutions, and then establish the existence of tempered random bounded absorbing sets and global random attractors.

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CP5

Black Holes As Inducers of Light

Soon gravitational waves will be another tool for observing our cosmos. Among interesting systems, those that can radiate in both gravitational and electromagnetic waves stand out as ideal candidates to probe deeply into our understanding of physics at extreme regimes. In this talk i'll discuss a few systems, efforts to study them and significant results obtained through different efforts.

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CP5

Surface Wave Packet Propagation over Flat and Slowly Varying Bottoms

The initial value problem of the one-dimensional nonlinear Schrödinger (NLS) equation with constant coefficients can be solved by using compact finite difference scheme. In this talk, the similar scheme is implemented in the signaling problem of the one-dimensional NLS equation with constant coefficient where it describes the propagation of surface gravity wave packet over flat bottom. Various examples are illustrated. The similar compact finite difference scheme is applied further in the signaling problem of the one-dimensional NLS equation with variable coefficients which models the surface wave packet propagation over slowly varying bottom.

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CP6

The Propagation of Finite Amplitude Pressure Waves Through a Gas with a Step Temperature Profile

A numerical study of wave propagation through gases with a step temperature distribution will be presented. This is done to identify the physical mechanisms underlying the reflection and transmission that occur when a high-intensity pressure wave interacts with a temperature gradient. Particular emphasis is paid to the effects of nonlinearity through comparison with the acoustic case. An understanding of these mechanisms will aid in the evaluation of thermal barrier effectiveness in attenuating nonlinear waves.

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CP6

Radiating Instabilities of Zonal Jets in a Rotating Ocean

We consider interaction of internal gravity waves and a zonal surface current (such as the Gulf Stream) within the framework of the reduced gravity shallow water model for a rotating ocean. Two aspects of the problem are studied: the scattering of each individual wave by the jet and the collective effect that weak wave turbulence impose on the mean flow. The wave equation contains so-called critical layer where momentum exchange between the mean flow and waves occurs resulting in over-reflection or absorption of the latter. Inertially unstable flows generate propagating wave instabilities where gravity waves are spontaneously emitted.

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CP6

Transversal Waves of Dual Perturbations of the Poiseuille Flow

Spatiotemporal cascades of dual perturbations of the transitional Poiseuille flow are considered. Three alternative approaches to the cascade description through a spatial cascade, a temporal cascade, and a spatiotemporal cascade are compared. Duality of displayed and hidden perturbations is resolved through invariant differential structures of Jacobian elliptic functions and justified by an asymptotic Hamiltonian approach.

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CP6

Singularities in the Complex Physical Plane for

Deep Water Waves

Results from boundary integral techniques for deep water waves indicate the presence of singularities in the complex arclength plane. These singularities move about the complex plane and can approach closely to the real axis and are associated with the high curvature at the tip of a plunging breaker. Moreover, direct confirmation has been established between our numerical result and Tanveer's theoretical prediction of square-root singularities. In addition, square-root singularities are also present in the wave elevation as a function of the complex horizontal coordinate. These singularities reach the real axis in finite time when the wave breaks.

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MS1

Modulation Induced Photonic Transition: Optical Isolation

Dynamic refractive index modulation can be used to induce transitions between photonic states. We show that such modulation can be used to achieve complete, linear, optical isolation, as well as achieving single-pole optical resonances with completely tunable linewidth and resonant frequency.

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MS1

Nonlinear Digital Holography at the Micro- and Nano-scale

Digital holography is a hybrid technique that combines physical measurement of a wave field with numerical propagation. Here, we extend the propagation kernel to include the effects of spatial nonlinearity. Nonlinearity mixes high-frequency spatial modes with low-frequency ones, so that all linear limits on imaging are superseded. In this talk, we describe the experimental and theoretical issues involved with nonlinear digital microscopy in the non-paraxial and sub-wavelength regimes.

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MS1

Novel Lasing Structures and Phenomena from Steady-State Ab Initio Theory

Abstract not available at time of publication.

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MS2

Critical Asymptotics for the KdV Equation in the Small Dispersion Limit

Abstract not available at time of publication.

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MS2

Computing Asymptotic Behavior for Singularly Perturbed Semilinear Partial Differential Equations

We describe the Chebyshev spectral integration method for computing high resolution numerical solutions to partial differential equations with non-periodic boundary conditions. We then examine numerical solutions to singularly perturbed equations. The first set of equations are damped nonlinear equations arising from viscoleastic models for solids, these models include fourth order derivatives which are multiplied by a small coefficient. We show that it is possible to compute the dynamics of these models and to compute the theoretically predicted scaling with the coefficient of the highest order term for minimizers of the energies of these models. The second set of equations are integrable wave equations, and include the KdV and nonlinear Schrödinger equations. Numerical solutions are demonstrated in one and two dimensions in the two dimensional case, a Fourier-Chebyshev discretization is used. Portions of this are joint work with Christian Klein and Kristelle Roidot.

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MS2

Interaction of Highly Oscillatory Waves in Weakly Nonlinear Schroedinger Equations

We consider weakly nonlinear Schroedinger equations in a semi-classical scaling and study the interaction of highly oscillatory waves within this context. A geometrical description of possible resonances for cubic case is given. A rigorous semi-classical approximation result is stated, using the analytical framework of Wiener algebras. Finally, some applications and extensions (for example Hartree type nonlinearities) are discussed.

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MS2

Initial Value Problem of the Whitham Equations for the Camassa-Holm Equation

Like the KdV equation, the Camassa-Holm equation with small dispersion can be viewed as a dispersive approximation to the inviscid Burgers equation. Although the zero dispersion limit for the Camassa-Holm equation has not been established, the modulation equations have been derived. These modulation equations are first order quasilinear hyperbolic partial differential equations. Unlike the KdV case, the modulation equations for Camassa-Holm are non-strictly hyperbolic. In this talk, we will discuss the initial value problem related to these modulation equations.

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MS3

Counterflow Induced Modulational Instability, Vector Solitons, and Vector Dispersive Shock Waves

Modulational instability (MI) due to relative motion of two fluid components is predicted and experimentally observed for a miscible, binary Bose-Einstein condensate (BEC). Stability analysis reveals the critical relative speed for the onset of counterflow induced MI in the two component, repulsive (defocusing) vector Nonlinear Schrödinger equation. These results are corroborated by experiment and three-dimensional numerical simulations where a proliferation of dark-dark vector solitons, possibly experiencing a transverse (snake) instability, occurs. In contrast, for relative speeds below critical, there is a smooth counterflow accompanied by nonlinear self-steepening which leads to the development of vector dispersive shock waves composed of trains of dark-bright solitons.

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MS3

Spin Dynamics in Spinor Dipolar BECs

We study the spin dynamics in a spin-1 ferromagnetic Bose-Einstein condensate (BEC) with magnetic dipole-dipole interaction within the mean-field theory. We find that various magnetic structures such as checkerboards and stripes emerge in the course of the dynamics due to the rather complicated combined effects of spin-exchange and magnetic dipole-dipole interactions, quadratic Zeeman, and finite size effects, and non-stationary initial conditions. However, the short-range magnetic pattern observed by the Berkeley group [Phys. Rev. Lett. **100**, 170403 (2008)] is not reproduced in our calculations. In this talk, we discuss the agreements and discrepancies between our numerical calculation and the experiment.

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MS3

Spontaneous Symmetry Breaking of Bose-Fermi Mixtures in Double-Well Potentials

We study the spontaneous symmetry breaking (SSB) of a superfluid Bose-Fermi (BF) mixture in a double-well potential (DWP). The mixture is described by the Gross-Pitaevskii equation (GPE) for the bosons, coupled to an equation for the order parameter of the Fermi superfluid. Straightforward SSB in the degenerate Fermi gas loaded into a DWP is impossible, as it requires an attractive self-interaction, while the intrinsic nonlinearity in the Fermi gas is repulsive. We demonstrate that the symmetry breaking is possible in the mixture with attraction between fermions and bosons. Numerical results are represented by dependencies of asymmetry parameters for both components on numbers of fermions and bosons in the mixture, and by phase diagrams which displays regions of symmetric and asymmetric ground states. The dynamical picture of the SSB, induced by a gradual transformation of the single-well potential into the DWP, is reported too. An analytical approximation is proposed for the case when GPE for the boson wave function may be treated by means of the Thomas-Fermi (TF) approximation, allowing one to reduce the model to a single equation for the fermionic function, which includes competing repulsive and attractive nonlinear terms.

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MS3

Higher-order Correction to Mean-field Evolution for Interacting Bosons

I will describe recent progress, and open challenges, in the study of PDEs that aim to transcend the Gross-Pitaevskii equation. The derivation relies on the use of Boson operators in a Fock space, following arguments of Lee, Huang, Yang, and Wu, who invoked the excitation of particles in pairs from the condensate to other states. Some implications will be discussed.

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MS4

Coarse-grained Molecular Dynamics Models

We will present a coarse-grained model based on molecular dynamics. The goal is to reduce the dimension of the problem by chooses a small set of coarse-grained variables. We will discuss how to derive the effective equations for the selected variables, and how to sample random noise based on fluctuation-dissipation theorem.

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MS4

Coagulation and Annihilation Reactions in Subdiffusive Media

We consider reactions between particles whose mean square displacement on a lattice is subdiffusive. One subdiffusion scenario is a lattice of traps with a particular distribution of depths. Another is a translationally invariant lattice with power law escape time distributions from each trap. While both lead to similar mean square displacements, the distributions of particles over sites vs time and the effects of reactions on these distributions may be very different in the two cases.

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MS4

Non-equilibrium Statistical Mechanics, Billiards, and Large Deviations

We discuss simple but realistic models of non-equilibrium statistical mechanics where systems of particles are submitted to external forces and coupled to suitable thermostats: (a) billiard with Gaussian thermostats and (b) particle systems coupled at the boundary to heat reservoirs. We study rigorously non-equilibrium steady states for such systems focussing on the entropy production, its fluctuations, and the Gallavotti-Cohen fluctuation theorem.

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MS4

A Stochastic Boundary Forcing Model for Simulating Wave Turbulence Systems

The beta-Fermi-Pasta-Ulam (FPU) model can serve as an example of a discretized wave turbulence system with four-wave nonlinear interactions. We present a stochastic boundary forcing technique for the numerical simulation of a subdomain of a periodic beta-FPU chain, with a view toward modeling the correct time evolution of the energy spectrum more accurately than conventional periodic boundary conditions would.

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MS5

Renormalized Resonances in Wave Turbulence

We study the non-perturbative nature of wave turbulence in strongly nonlinear regimes. We demonstrate that nonlinear wave interactions renormalize the dynamics, leading to (i) a drastic deformation of the resonant manifold even at weak nonlinearities, and (ii) creation of nonlinear resonance quartets in wave systems for which there would be no resonances as predicted by the linear dispersion relation. Finally, we present an extension of the weak turbulence kinetic theory to systems with strong nonlinearities.

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MS5

Wave Propagation in Deformed Waveguides: A Unifying Approach

Using a conformal change of coordinate, we map a PDE on a 2D complicated strip to an inhomogeneous PDE in a rectangle. This can be reduced to a 1D effective equation by averaging. Using the SchwarzChristoffel transformation for polygons and its numerical implemention by Driscoll we studied this reduction for the Boussinesq system in a river with variable width and the sine-Gordon equation in a deformed strip.

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MS5

Influence of the Condensate on the Wave Turbulence Spectra

During direct numerical simulation of the isotropic turbulence of surface gravity waves in the framework of Hamiltonian equations formation of the long wave background or condensate was observed. Exponents of the direct cascade spectra at the different levels of an artificial condensate suppression show a tendency to become closer to the prediction of the wave turbulence theory at lower levels of condensate. A simple qualitative explanation of the mechanism of this phenomenon is proposed.

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MS5

Strong Collapse Turbulence in Nonlinear Schrödinger Equation

We consider a nonlinear Schrödinger equation (NLS) with dissipation and forcing in critical dimension. Without both linear and nonlinear dissipation NLS results in a finite-time singularity (collapse) for any initial conditions. Dissipation ensures collapse regularization. If dissipation is small then multiple near-singular collapses are randomly distributed in space and time forming collapse turbulence. Collapses are responsible for non-Gaussian tails in the probability distribution function of amplitude fluctuations which makes turbulence strong. Power law of non-Gaussian tails is obtained for strong NLS turbulence.

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MS6

Time-Periodic Solutions of Nonlinear Dispersive Equations

Together with Jon Wilkening, the speaker has developed a numerical method for the computation of time-periodic solutions of nonlinear systems of partial differential equations. The method so far has been applied to the Benjamin-Ono equation and to the vortex sheet with surface tension. For Benjamin-Ono, we find bifurcation from traveling waves to nontrivial time-periodic solutions. For the vortex sheet with surface tension, we find bifurcation from the flat equilibrium.

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MS6

Solitons Bifurcating from Band-edges in Periodic Media

Nonlinear Schrodinger (NLS) / Gross-Pitaveskii (GP) equations with periodic potentials are useful for modeling the nonlinear dynamics arising in various physical systems, such as propagation laser beams, Bose-Einstein condensates, and deep water waves. These equations can admit positive bound state solutions (aka solitons) that bifurcate from zero as the frequency bifurcates from the edge of the first spectral band into the semi-infinite gap. We prove that to leading order near the band edge, the bound state is a product of a rapidly oscillation Bloch wave and a slowly-varying ground state solution of a homogenized equation, whose coefficients depend on the effective-mass tensor and coupling constants. Explicit expressions are derived for these coefficients. In the L2-critical case, these results imply that the L2 norm (power) of the bound state is below the threshold for singularity, yet that the slope condition for stability is violated. The ensuing dynamics of perturbed bound states is elucidated by direct computations of NLS / GP equations.

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MS6

A System of ODEs For a Perturbation of a Minimal Mass Soliton

We study soliton solutions to a nonlinear Schrödinger equation with a saturated nonlinearity. Such nonlinearities are known to possess minimal mass soliton solutions. We consider a small perturbation of a minimal mass soliton, and identify a system of ODEs similar to those from the work of Comech-Pelinovsky, which model the behavior of the perturbation for short times. We then provide numerical evidence that under this system of ODEs there are two possible dynamical outcomes, which is in accord with earlier conclusions of Pelinovsky. For initial data which supports a soliton structure, a generic initial perturbation oscillates around the stable family of solitons. For initial data which is expected to disperse, the finite dimensional dynamics follow the unstable portion of the soliton curve.

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MS6

Coherent Structures in the Nonlinear Maxwell Equations

The primitive equations governing wave propagation in spatially varying optical fibers are the nonlinear Maxwell equations, though this process is often modeled using the nonlinear coupled mode equations (NLCME). NLCME describe the evolution of the slowly varying envelope of an appropriate carrier wave. They are known to possess solitons, which may be of use in optical transmission. In this talk, we numerically study the evolution the NLCME soliton in the primitive equations, and find them to be robust. This is highly non-trivial, as the nonlinear Maxwell equations are a non-convex hyperbolic system, requiring careful treatment of the Riemann problem. Furthermore, we consider extensions of NLCME to a system of infinitely many nonlinear coupled mode equations and present some results suggesting this new system also possesses localized states. This work is in collaboration with D. Pelinovksy and M.I. Weinstein.

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MS7
Recent Results in Evans Function Computation

Recent Results in Evans Function Computation In this talk we discuss some of our recent work in multi-D Evans function computation. Although our techniques can be applied broadly, we are motivated by the stability analysis of viscous shock layers in compressible fluid flow. A number of unexpected analytical and numerical wrinkles have shown up in our multi-D studies, and we demonstrate how we have been able to overcome them.

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MS7
Computing Stability of Multi-dimensional Waves

We present a numerical method for computing the pure-point spectrum associated with the linear stability of multidimensional travelling fronts to parabolic nonlinear systems. Our method is based on the Evans function shooting approach. Transverse to the direction of propagation we project the spectral equations onto a finite Fourier basis. This generates a large, linear, one-dimensional system of equations for the longitudinal Fourier coefficients. We construct the stable and unstable solution subspaces associated with the longitudinal far-field zero boundary conditions, retaining only the information required for matching, by integrating the Riccati equations associated with the underlying Grassmannian manifolds. The Evans function is then the matching condition measuring the linear dependence of the stable and unstable subspaces and thus determines eigenvalues. As a model application, we study the stability of two-dimensional wrinkled front solutions to a cubic autocatalysis model system.

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MS7
Stability in Multi-dimensional Problems via Evans Functions and Lyapunov-Schmidt

In this talk, I will give an overview of different methods for assessing the stability of waves on multi-dimensional cylindrical domains and illustrate these by examples. Specifically, I will discuss a stability parity index for spatially periodic waves on cylindrical domains, the stability of planar patterns via a reduction of an infinite-dimensional Evans function, and the stability of fast pulses of the discrete FitzHugh-Nagumo equation near its singular limit using Lyapunov-Schmidt reduction based on exponential dichotomies.

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MS8
Homoclinic Snaking with Phase-winding States

Many pattern forming systems contain a multiplicity of coexisting stationary spatially localized states. The spatial dynamics of such systems is characterized by homoclinic orbits which are organized around heteroclinic cycles between a fixed point and a periodic orbit. These states occupy an extended region in parameter space called the snaking region. A similar behavior is present in systems which contain heteroclinic orbits between two fixed point, though in this case the solutions collapse to a single point in parameter space. In this talk I present a novel hybrid example involving phase winding states in the forced complex Ginzburg-Landau equation, which combines aspects from both types of behavior: homoclinic snaking associated with a heteroclinic connection between a fixed point and a periodic orbit which collapses to a point in parameter space.

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MS8
Localized Patterns in Large But Finite Domains

Common sense dictates that, in large domains, boundaries have a negligible influence on pattern formation and periodic boundary conditions are therefore often adopted for simplicity. For localized patterns however, this can be a dangerous modeling attitude. The effect of distant boundaries balances with exponentially small pinning forces acting on the edges of the patterns. Using asymptotics, we find that they can only occupy discrete locations. This limits the information capacity of such nonlinear systems.

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MS8

Defect-mediated Snaking: A New Growth Mechanism for Localized Structures

The forced complex Ginzburg-Landau equation with 1:1 and 1:2 resonance exhibits a new type of homoclinic snaking involving a single branch of stationary spatially localized states. The states on this branch grow from a central defect that inserts new rolls on either side, while pushing existing rolls outwards. This growth mechanism differs fundamentally from standard homoclinic snaking in which new rolls are added at the fronts that connect the structure to the background homogeneous state.

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MS8

Localized Structures in the Multi-dimensional Swift-Hohenberg Equation

The bifurcation structure and the cessation of snaking of localized radial patterns of the Swift–Hohenberg equation are explored through numerical computations as the dimension is varied. Our findings elucidate the connection between one-dimensional pulses and 2-pulses to planar spots and rings when the dimension is changed from one to two and then further to three. We also discovered a new class of planar localized spot solutions and discuss an analytical approach to establishing their existence.

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MS9

Engineering Silicon Nanophotonic Waveguides for Mid-Infrared Nonlinear Optics

Silicon nanophotonic waveguides can be engineered to strengthen nonlinear optical interactions up to 100000 times those found in silica optical fibers. Therefore, the silicon platform can be utilized to realize a variety of ultra-compact low-power nonlinear optical devices, having applications including all-optical signal processing, parametric light source generation, and sensing. This talk will explore nonlinear optics in silicon waveguides, highlighting the recent demonstration of a mid-infrared optical parametric amplifier exhibiting large on- and off-chip gain.

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MS9

Designable Nonlinearities in Optomechanically-active Photonic-crystal Waveguides

We design large, tunable optical nonlinearities in waveguides that are repositioned via optical forces. Light in the waveguides exerts a mechanical force between either parallel waveguides or waveguide and substrate. We calculate intensity-dependent changes in phase birefringence up to 0.026 for pump powers of 20mW. This effect enables switchable linear-to-circular polarization conversion within compact devices. We further calculate mechanical Kerr coefficients resulting from optical forces in silicon strip waveguides and 1D photonic- crystal waveguides. We show that waveguide displacements responsible for the Kerr effect are enhanced close to the light line and near the photonic band gap.

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MS9

Nonlinear Optics (At a Single Photon Level) in Photonic Crystal Nanocavities

A strong localization of light inside optical nanocavities can be employed to demonstrate nonlinear optical effects at ultra-low thresholds, with applications ranging from optical switches and modulators controlled with sub-fJ energies, to inexpensive light sources in the visible. We have employed photonic crystal nanocavities in III-V semiconductors to demonstrate frequency conversion of weak optical beams between infrared and visible wavelengths. In addition, a single semiconductor quantum dot strongly coupled to an optical nanocavity has been employed to demonstrate controlled amplitude and phase shifts of an optical beam reflected from such a cavity, with control beams at the single photon level.

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MS10

Dissipative Droplet Solitons

Large amplitude, vectorial, localized, "droplet solitons" in anisotropic magnetic media are studied in thin ferromagnetic films driven by a spin polarized current. This 2D dissipative droplet soliton is an approximate solution of a modified Landau-Lifshitz equation and results from a balance between a spatially localized forcing and a uniform damping in addition to nonlinearity and dispersion. Using perturbative techniques and numerical calculations, properties of this strongly nonlinear, coherently precessing state will be discussed including existence conditions, stability, and hysteresis. Furthermore, motivated by a numerically observed drift instability, moving droplet solitons will also be discussed.

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MS10

Influence of Free and SAF Layer Oscillations Modes on the RF Emission Line Width in Magnetic Tunnel Junctions

We present a numerical study of oscillation modes in magnetic tunnel junctions and investigate the frequency/FWHM as a function of applied current. We show that the linewidth reaches a min. of 14.5MHz at the threshold current, and increases sharply to 308MHz as the current is increased. The line-narrowing is due to an increased coherence of the uniform precession mode, while the line-broadening above threshold arises from the intrinsic oscillator nonlinearity combined with overlapping contributions from edge modes.

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MS10

Two-dimensional Electromagnetic Solitons in the Short-wave Approximation

Using a short wave approximation, the Maxwell-Landau equations describing electromagnetic wave propagation in a thick saturated ferromagnetic film are reduced to two-dimensional asymptotic models which generalize the sine-Gordon (sG) equation, and admit a Lagrangian in contrast to the so-called 2 dimensional sG equation. Depending on the orientation of the external field, symmetry can be broken. Unstable line solitons decay spontaneously into lumps, which are described by both numerical and variational approaches.

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MS10

Devil's Staircase in Nano-magnetism: Fractional Synchronization of a Spin-torque Nano-oscillator

When an oscillator with auto-oscillation frequency ω_0 is driven by a strong external periodic signal of frequency ω_e, it can become synchronized at any rational value of $r = \omega_e/\omega_0$. Here, we show that by driving a spin-torque nano-oscillator (STNO) with a microwave magnetic field at oblique direction with respect to the STNO symmetry axis, it is possible to observe integer ($r = 1, 2, 3, 4$) and fractional ($r = 3/2, 7/3, 5/2, 7/2$) synchronization regimes, forming a so-called "Devil's staircase".

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MS11

On the Small Dispersion Limit for Camassa-Holm Equation

I shall present recent results obtained in collaboration with Christian Klein (Univ. Bourgogne, France) and Tamara Grava (Sissa, Italy) on the so-called small dispersion limit of solutions of the Cauchy problem of the Camassa Holm (CH) equation for smooth initial data such that wave-breaking does not occur. For initial data in this class, the numerical solution of (CH) develops a zone of fast oscillations, as for the small dispersion limit of the Korteweg-de Vries equation and asymptotic expansions shall be proposed.

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MS11

Universality Behviour of Solutions of Hamiltonian PDEs in Critical Regimes

We study solutions to a family of Hamiltonian PDEs near critical points. We show that the local behaviour of the solutions near the critical points is described by a family of ODE of Painleve' type. We show that up to shifts, rescalings and Galileian transformations, this local description does not depend on the initial data nor on the equation.

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MS11

Numerical Treatment of the Small Dispersion Limit in Nonlinear PDE

Purely dispersive equations as the Korteweg-de Vries and the nonlinear Schrödinger equation and two dimensional generalizations in the limit of small dispersion have solutions to Cauchy problems with smooth initial data which develop a zone of rapid modulated oscillations in the region where the corresponding dispersionless equations have shocks or blow-up. Fourth order time-stepping in combination with spectral methods is beneficial to numerically resolve the steep gradients in the oscillatory region. We compare the performance of several fourth order methods for exact solutions and the small dispersion limit: exponential time-differencing fourth-order Runge-Kutta methods (Cox and Matthews, Krogstad, Hochbruck and Ostermann) in the implementation by Kassam and Trefethen, integrating factors, time-splitting, Driscoll's composite Runge-Kutta scheme, and an ODE solver in Matlab.

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MS12

Quantum Many-body Systems, the Nonlinear Schrodinger Equation, and Beyond

Only recently has the rigorous connection been made between the many-body physics of Bose-Einstein condensation and the mathematics of the macroscopic model, the cubic nonlinear Schrodinger equation. I'll discuss work on two-dimensional cases for Bose-Einstein condensation–especially the periodic case, because of techniques from analytic number theory and applications to quantum computing. I'll also mention work on a high-probability phase transition for invariant measures of the NLS.

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MS12

Dynamics of Solitary Waves in Double Well Potentials Motivated by BEC

We present some models motivated by studies of Bose-Einstein condensates trapped in double-well potentials. We extend the analysis of the prototypical 1D model with local nonlinearity to spatially varying collisional interactions, long-range interactions, and also the 2D environment in the setting of a four-well potential. By a Galerkin-type few-mode approach, we study the existence, stability and dynamics of the nonlinear localized steady states and predict the bifurcation diagrams.

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MS12

Dynamics of Quantized Vortices in Bose-Einstein Condensates

The dynamics and interaction of quantized vortices in Bose-Einstein condensates (BECs) are presented in this talk. If all vortices have the same winding number, they would rotate around the trap center but never collide. In contrast, if the winding numbers are different, their interaction highly depends on the initial distance between vortex centers. The analytical results are presented to describe the dynamics of the vortex centers in non-interacting BEC. While in interacting BEC, there is no analytical result but some conclusive numerical findings are provided for the further understanding of vortex interaction in BECs. Finally, the dynamic laws describing the relation of vortex interaction in nonrotating and rotating BECs are presented.

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MS13

Existence and Stability of Fully Localised Three-dimensional Gravity-capillary Solitary Water Waves

A solitary wave of the type advertised in the title is a critical point of the Hamiltonian, which is given in dimensionless coordinates by

$$H(\eta,\xi)=\int_{\mathbf{R}^2}\left\{\frac{1}{2}\xi G(\eta)\xi+\frac{1}{2}\eta^2+\beta\sqrt{1+\eta_x^2+\eta_z^2}-\beta\right\},$$

subject to the constraint that the impulse

$$I(\eta,\xi)=\int_{\mathbf{R}^2}\eta_x\xi$$

is fixed. Here $\eta(x,z)$ is the free-surface elevation, ξ is the trace of the velocity potential on the free surface, $G(\eta)$ is a Dirichlet-Neumann operator and $\beta > 1/3$ is the Bond number. In this talk I show that there exists a minimiser of H subject to the constraint $I = 2\mu$, where $0 < \mu \ll 1$. The existence of a solitary wave is thus assured, and since H and I are both conserved quantities its stability follows by a standard argument. 'Stability' must however be understood in a qualified sense due to the lack of a global well-posedness theory for three-dimensional water waves.

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MS13

Instability of Periodic Water Waves

Periodic traveling waves exist in 2D water waves and lots of dispersive models, such as Stokes waves of deep water (Stokes, 1847) and Cnoidal waves of KDV equation. I will discuss an unified approach to study the stability and instability of periodic waves of water waves and a large class of dispersive models, under perturbations of the same period. The results include a sharp instability criterion for KDV and BBM type models, and a proof of the existence of unstable Stokes waves under some natural assumptions.

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MS13
Existence and Stability of Solitary Waves on Water

The talk will discuss most recent development on the existence and stability of two- and three-dimensional waves on the surface of water of finite depth with or without suface tension using various model equations or exact Euler equations. It will be shown that in some special cases, these equations have solitary-wave solutions. Moreover, various stability results for these waves will be addressed, such as transverse stability, spectral stability or conditional stability.

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MS14
Localized and Periodic Patterns in nonlinear Schrödinger Equation with Complex Potentials

Exact solutions for the generalized nonlinear Schrödinger (NLS) equation with inhomogeneous complex linear and nonlinear potentials are found. We have found localized and periodic solutions for a wide class of localized and periodic modulations in space of complex potential and nonlinearity coefficient. Applications for the case of PT symmetry are discussed.

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MS14
Matter Waves in Complex Potentials

Inelastic interactions of condensed atoms with an external trap in the mean-field approximation lead to the Gross-Pitaevskii equation with a complex potential. If the atomic losses are compensated by a linear gain, stable patterns of the matter emerge. Such nonlinear dissipative structures appear as attractors and are characterized by the balance of the dispersion and the nonlinearity due to two-body interactions, one the one hand, and on the other hand due to equilibrium between the losses and gain. In the talk there will be reported the results on dynamics of matter waves in dissipative optical lattices and in a dissipative parabolic trap. The results to be reported are obtained in collaboration with Yu. V. Bludov, G. L. Alfimov, and D. Zezyulin.

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MS14
Architectural and Functional Connectivity in Scale-free Integrate-and-fire Networks

We present a study of scale-free networks of identical, conductance-based, stochastically driven, integrate-and-fire excitatory neurons. Using the mean-field approach, we show that the firing rates of neurons in scale-free networks themselves follow scale-free distribution. At the same time we show that the firing rate in such networks is strongly dependent on the degree correlation function. The analytical results are compared to the direct numerical simulations of the coupled integrate-and-fire neurons. Ultimately, our analysis provides a link between the functional and anatomical connectivity in scale-free networks.

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MS14
Bubble Break-up as a Two-dimensional Free Hydrodynamics Problem

Break-up of gas bubbles immersed in liquids is a natural event occurring in many multiphase systems. Associated to this event is a process of gas neck reconnection. Recent experiments performed in University of Chicago have shown that neck reconnection is a non-universal process with the outcome strongly dependent on the initial conditions. In this talk I will show how the neck reconnection dynamics can be described with a two-dimensional free surface hydrodynamic model. This model can be e?ectively solved numerically with conformal mapping techniques that were introduced in the works of S. Tanveer and V. Zakharov et.al. I will present the results of numerical simulations which show that the smooth contact of bubble surface is a generic outcome of the dynamics, but the ?nal shape of the neck is strongly dependent on the initial conditions. I will also discuss possible extensions of this model that include the e?ect of large scale velocity and non-trivial topologies of the interface.

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MS15

Quantum Decay Rates for Manifolds with Hyperbolic Ends

Mathematically, quantum decay rates appear as imaginary parts of poles of the meromorphic continuation of Greens functions. As energy grows, decay rates are related to properties of geodesic flow and to the structure at infinity. For a cusp, infinity is small, which typically slows decay. However, I will present a class of examples for which decay rates go to infinity with energy even in the presence of a cusp. This is part of a more general investigation of resonances on manifolds with hyperbolic ends.

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MS15

Improved Regularity for H^1 log-log Blow-up Solutions to the L^2 Critical NLS

We prove that if $u(t)$ is a log-log blow-up solution, of the type studied by Merle-Raphael (2001–2005) to the 1-d L^2 critical focusing NLS equation $i\partial_t u + \partial_x^2 u + |u|^4 u = 0$ with initial data $u_0 \in H^1$ then $u(t)$ remains bounded in H^1 away from the blow-up point. This is obtained without assuming that the initial data u_0 has any regularity above H^1. As an application, we construct an open subset of initial data in $H^1_{rad}(\mathbf{R^3})$ (radial $H^1(\mathbf{R^3})$ functions) with corresponding solutions that blow-up on a sphere at positive radius for the 3d quintic ($\dot{H}^1$-critical) focusing NLS equation $i\partial_t u + \Delta u + |u|^4 u = 0$.

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MS15

Estimates on the Strichartz Norm for Small Solutions of the L^2-critical NLS Equation

We consider the mass-critical Schroedinger equation in 1 and 2 space dimensions (both focusing and defocusing cases). By Strichartz estimates for the linear problem, solutions with small L^2 norm are globally defined and belong to an L^p (Strichartz) space (here, $p = 6$ in 1d and $p = 4$ in 2d). We show that for small L^2 norm the maximum of the L^p (Strichartz) norm is attained, and give a precise estimate of this maximum as the mass tends to 0. In particular, in the focusing case, it is greater than the corresponding maximum for the linear equation, which was computed by Foschi and Hundertmark-Zharnitsky, and it is smaller in the defocusing case. This is a joint work with T. Duyckaerts and F. Merle.

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MS15

Collapsing Vortex Soliton Blowups for L^2-critical NLS

The focusing cubic nonlinear Schrodinger equation in two dimensions admits vortex solitons with spin m. These are generalizations of the standard soliton (spin $m = 0$) and have spatial structure, $Qm(r, \theta) = e^i m\theta Rm(r)$. In the case of no spin, it is well known [Merle & Raphael] that there exists an open class of solutions in H1 that blowup at the log-log rate by concentrating precisely the L2 norm of the soliton into a point. We prove that, in the case of spin $m = 1$, there is a relatively open class of data that blowup at the log-log rate by concentrating the L2 norm of the Q1 vortex soliton into a point. These are the first examples of log-log blowups that focus strictly more than the L2 norm of the soliton. Our proof is in two parts. We show that, when restricted to functions of the same spin, the degeneracies and algebraic structure of the Hamiltonian near the vortex soliton are the same as in the spinless case. In particular, a similar modulation argument is possible, assuming a crucial spectral property holds. In the case $m = 1$, we use numerical techniques to show that the spectral property is indeed true.

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MS16

Eigenvalues of Embedded Solitons

Abstract not available at time of publication.

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MS16

A Connection Between Parametric Resonance and Bike Tracks

This talk describes a surprisingly close connection between objects mentioned in the title.

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MS16

Stability and Instability of Kink-wave Solutions to the Sine-Gordon Equation

We give a proof for the conditions of stability and of instability of certain traveling wave solutions to the sine-Gordon equation. For a traveling kink wave solution of speed c, the kink wave is stable if and only if $c^2 - 1 < 0$. The proof uses the Maslov index as a means for determining both the unstable and stable case. Ricatti equations and fur-

ther geometric considerations are also used in establishing stability.

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MS16

On a DNA Model based on Coupled Oscillators with Interactions up to Three Neighbors Away

We will introduce a DNA model based on coupled oscillators interacting with neighbors up to three bases away. First, we will show results regarding the hyberbolicity of the fixed point at the origin. We will proceed with the stability analysis of static solutions and will show new types of solutions, in comparison with the nearest-neighbor model. Finally, we will present results on the modulational instability of plane waves and the stability of breathers.

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MS17

Renormalization Group Apprach to Semi-strong Interactions

This talk is based on joint work with P. v.Heijster, A. Doelman, and K. Promislow. We develop a renormalization group method to rigorously derive equations of motion for the positions of N fronts interacting semi-strongly in the three-component extended FitzHugh-Nagumo system.

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MS17

Wave Stability in Systems with a Non-strictly Hyperbolic Part

In this talk we present resolvent estimates for hyperbolic-parabolic systems, where the hyperbolic part need not be strictly hyperbolic (e.g. Hodgkin-Huxley equation). It is shown that these imply the stability of traveling waves, fronts and pulses, as well as the convergence of the freezing method [Beyn, Thmmler 2004]. Our results generalize those of [Kreiss, Kreiss, Peterson 1994] and also include systems that are not covered by the invariant manifold approach of [Bates, Jones 1989]. Numerical experiments will be presented for illustration.

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MS17

Interaction Manifolds in Reaction Diffusion Systems

We consider a general planar reaction diffusion equation which we hypothesize has a localized traveling wave solution. Under assumptions which are no stronger than those needed to prove the stability of a single pulse, we prove that the PDE has solutions which are roughly the linear superposition of two pulses, so long as they move along trajectories which are not parallel. In particular we prove that if the initial data for the equation is close to the sum of two separated pulses, then the solution converges exponentially fast to such a superposition so long as the distance between the two pulses remains sufficiently large.

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MS17

Fronts in Heterogeneous Media

In this presentation, we analyze the influence of heterogeneities on localized solutions to a three-component system of FitzHugh-Nagumo type. It turns out that the heterogeneity pins the solutions. More specifically, traveling front solutions can be pinned at the heterogeneity and from a 1D-familiy of stationary pulse solutions (in the homogeneous case), the heterogeneity case only picks a few.

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MS18

Noise Induced Pulse Interaction: The Casimir Effect in Mode Locked Lasers

Ultrashort pulses in a multi-pulse passively mode locked lasers exhibit rich dynamics, behaving as a system of interacting particle-like entities. An important mechanism for the inter-pulse interactions is continuum light radiated and absorbed by the pulses. Statistical light-mode dynamics (SLD) is the established method for analyzing the fluctuating dynamics of the pulse-continuum optical field of the mode locked laser; using SLD we identify a noise-induced long-range attractive interaction between pulses that is an entropic effect, quite reminiscent of the Casimir attraction in quantum electrodynamics. In combination with a gain-induced repulsive attraction we present the first complete theory of the formation of steady-state pulse 'molecules' with stable inter-pulse spacings in multi-pulse mode locked lasers.

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MS18

General Features of Dissipative Soliton Resonances: A Roadmap for High-energy Optical

Pulses?

A Dissipative Soliton Resonance (DSR) consists in the increase to infinity of the energy of dissipative solitons when the propagation equation parameters converge to a specific set of values. Using the complex cubic-quintic Ginzburg-Landau equation, we confirm the existence of DSRs for wide ranges of parameters in both chromatic dispersion regimes, and establish general features of the ultra-high energy pulses found close to a DSR. Relationship to high-energy mode-locked fiber oscillators is proposed.

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MS18

Amorphous Photonic Lattices: Fundamentals and Applications

We present, theoretically and experimentally, a new concept in photonics: amorphous photonic lattices. These structures exhibit a band gap and negative effective mass, without any Bragg diffraction. We show that in these systems the bands are comprised of localized Anderson states, but defect states residing in the gap are much stronger localized. The underlying fundamental physics and potential applications are discussed, including the intriguing possibility of fabricating a hollow-core disordered photonic band-gap fiber.

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MS19

Resonant Nonlinear Damping of Quantized Spin Waves in Ferromagnetic Nanowires

We use ferromagnetic resonance excited by spin transfer torque from alternating spin-polarized current to measure the spectral properties of dipole-exchange spin waves in permalloy nanowires. Our measurements reveal that geometric confinement has a profound effect on the nonlinear damping of spin waves in the nanowire geometry. The damping parameter of the lowest-energy quantized spin wave mode depends on applied magnetic field in a resonant way and exhibits a maximum at a field that increases with decreasing nanowire width. This enhancement of damping originates from a nonlinear resonant three-magnon confluence process allowed at a particular bias field value determined by quantization of the spin wave spectrum in the nanowire geometry.

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MS19

Ginzburg-Landau Model of Bose-Einstein Condensation of Magnons

We introduce a system of phenomenological equations for Bose-Einstein condensates of magnons in the one-dimensional setting. The nonlinearly coupled equations, written for amplitudes of the right- and left-traveling waves, combine basic features of the Gross-Pitaevskii and complex Ginzburg-Landau models. They include localized source terms to represent the microwave magnon-pumping field. With the source represented by delta-functions, we find analytical solutions for symmetric localized states of the magnon condensates. We also predict the existence of asymmetric states with unequal amplitudes of the two components. Numerical simulations demonstrate that all analytically found solutions are stable. With the delta-function replaced by broader sources, the simulations reveal a transition from the single-peak stationary symmetric states to multipeak ones, generated by the modulational instability of extended nonlinear-wave patterns. In the simulations, symmetric initial conditions always converge to symmetric stationary patterns. On the other hand, asymmetric inputs may generate nonstationary asymmetric localized solutions, in the form of traveling or standing waves. Comparison with experimental results demonstrates that the phenomenological equations provide for a reasonably good model for the description of the spatiotemporal dynamics of magnon condensates.

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MS19
Chaotic Solitons in Magnetic Thin Films

This presentation reports the observation of chaotic solitons in a magnetic film strip-based active feedback ring. At some ring gain level, one observes the self-generation of a spin-wave pulse whose amplitude changes with time in a chaotic manner. The pulse has a hyperbolic secant shape and a flat phase. The time-domain signal exhibits a finite dimension and a positive Lyapunov exponent. The results were confirmed by simulations based on the gain-loss nonlinear Schrodinger equation.

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MS20
On the Weakly Dispersive Shocks of the KP Equation

Recently, a large number of soliton solutions of the KP equation has been found and classified. In this talk, I will consider the weak dispersion limit of the KP equation, and discuss the weakly dispersive shock waves based on the classification of the soliton solutions.

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MS20
Fluxon Condensates and the Semiclassical Sine-Gordon Equation

The semiclassically scaled sine-Gordon equation is considered with (relatively) slowly varying initial data. Considered as functions of x, the initial conditions parametrize a curve in the phase portrait of the simple pendulum. We study the solution of the initial-value problem and show that away from points x where the initial data crosses the pendulum separatrix the solution is asymptotically described by modulated elliptic functions characterizing either breather trains or kink trains with superluminal velocities. Near points x where the initial data crosses the pendulum separatrix the behavior is more subtle. This is joint work with Robert Buckingham.

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MS20
On Meromorphic Solutions to the KdV Equation

We show that under the KdV flow an initial profile supported on (-8,0) from a very broad function class (without any decay assumption or certain type of behavior at minus infinity) instantaneously evolves into a meromorphic function with no poles on the real line. Our treatment is based on a suitable modification of the inverse scattering transform and a detailed investigation of the Titchmarsh-Weyl m-function. As by-product, we improve some related results of others.

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MS20
The Zero-dispersion Limit of the Benjamin-Ono Equation

We investigate the zero dispersion limit of the Cauchy problem of the Benjamin-Ono equation and provide the first rigorous results about it in this paper. We show this limit exists in the weak $L^2(R)$ sense and can be explicitly written in terms of the multivalued solution of the inviscid Burgers equation with the same initail condition.

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MS21
Pulse Switching in Nonlinear Optical Networks

An area of intense research is that of photonics, where light propagation features are controlled by clever engineering of periodic optical structures. In this presentation after we concentrate on one model: a novel photonic crystal coupler. The coupler is a novel system aim at producing controlled optical pulse delays. Here we demonstrate that the interplay of asymmetry in the design of each port with nonlinear effects produces optical pulses where we can control the group velocity.

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MS21
Bisolitons in Optical Fibers with Dispersion Management

Optical fiber links with dispersion management are known to be supporting propagation of stable coupled solitary wave solutions bisolitons. We theoretically demonstrated existence of an additional family of such solutions for the same set of system parameters. Energy of these solutions is shown to be larger then energy of conventional bisolitons. Direct numerical simulations demonstrated their stability.

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MS21

Methods for Large Deviations and Rare Events in Optical Fibers

In optical fiber systems, amplified spontaneous emission noise causes signal fluctuations that lead to errors in those rare cases when the noise-induced changes are large. We discuss methods capable of determining large deviations induced by noise in such systems. First, the large deviations are found using a constrained optimization problem that exploits the mathematical structure of the governing equations and a numerical implementation of the singular value decomposition. The results of the optimization problem then guide importance-sampled Monte-Carlo simulations to determine the events' probabilities. We show that the method works for a general class of intensity-based optical detectors and for arbitrarily shaped pulses.

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MS21

Impact of Raman Crosstalk on OOK and DPSK Massive Multichannel Transmission Systems

We investigate the effects of Raman crosstalk on the dynamics of pulse amplitudes in fiber optics communications systems with a large number of frequency channels. For OOK transmission we show that the nth normalized moments of the probability density function of the amplitude grow exponentially with both propagation distance and n. For DPSK transmission we find that the dynamics is described by an N-dimensional predator-prey model and show that stable transmission can be achieved by a proper choice of the frequency profile of the net gain/loss coefficients.

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MS22

Stability of Traveling Water Waves: Resonant Perturbations

A boundary perturbation algorithm will be presented for computing the spectral data of periodic traveling wave solutions to the potential flow equations. This algorithm extends the transformed field expansion technique of Nicholls (2002) to compute stability with respect to perturbations which resonate with the linear spectrum. The transformed field expansion approach will be motivated. The algorithm will be evaluated both as a modern tool, and with historical perspective.

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MS22

The Modulational Instability in the Presence of Dissipation and Forcing

Within the framework of the fully nonlinear water waves equations, we consider a Stokes wavetrain modulated by the Benjamin-Feir instability in the presence of both viscous dissipation and forcing due to wind. The wind model corresponds to the Miles' theory. By introducing wind effect on the waves, the present paper extends the previous works of [Segur *et al*, 2005, "Stabilizing the Benjamin-Feir instability", J. Fluid Mech.,539] and [Wu *et al*, 2006, "A note on stabilizing the Benjamin-Feir instability", J. Fluid Mech., 556] who neglected wind input. The marginal stability curve derived from the fully nonlinear numerical simulations coincides with the curve obtained by [Kharif *et al*, 2010, "The modulational instability in deep water under the action of wind and dissipation" (submitted)] from a linear stability analysis. Furthermore, it is found that wind input goes in the subharmonic mode of the modulation whereas dissipation damps the fundamental mode of the initial Stokes wavetrain.

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MS22

Linear Stability of Periodic Traveling Water Waves in Two and Three Dimensions

Several numerical methods have been devised to simulate not only traveling waveforms on the surface of an ideal fluid (the water wave problem) but also their dynamic stability. In this talk we will describe two robust and spectrally accurate Boundary Perturbation approaches to the problem of computation and linear stability of periodic water waves. We will present results in both two (Stokes waves) and three (short-crested waves) dimensions.

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MS22

Stability in the Euler Equations

Euler's equations describe the dynamics of gravity waves on the surface of an ideal fluid with arbitrary depth. In this talk, I discuss the stability of one-dimensional traveling wave solutions for the full set of Euler's equations via a generalization of a non-local formulation of the water wave problem due to Ablowitz, Fokas and Musslimani [Ablowitz *et al* 2006, J. Fluid Mech.]. Transforming the non-local formulation into a traveling coordinate frame, we obtain a new scalar equation for the stationary solutions using the original physical variables. Using this new equation, we develop a numerical scheme to determine traveling wave solutions by exploiting the bifurcation structure of the non-trivial periodic solutions. Next, we determine numerically the spectral stability for the periodic traveling wave solution by extending Fourier-Floquet analysis to apply to the non-local problem. We can generate the full spectra for all traveling wave solutions. In addition to recovering well-known results such as the Benjamin-Feir instability for deep water waves, we confirm the presence of high-frequency instabilities for shallow water waves. Finally, I discuss preliminary stability results of a two-dimensional surface with respect to two-dimensional perturbations.

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MS23

Justified Asymptotics for Gap Soliton Bifurcations from Gap Edges in Cubic 2D Schroedinger and Maxwell Models

Gap solitons in nonlinear periodic structures near spectral gap edges are formally approximated by slowly varying envelope models, coupled mode equations (CMEs). We provide a general technique for their derivation in the 2D Schrödinger and vector Maxwell models in Bloch variables. Using the Lyapunov-Schmidt reduction, we show which class of CME solutions ensures the existence of a corresponding solution of the original model and provide H^s bounds on the asymptotic approximation.

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MS23

Transition Metamaterials

Metamaterials open unparalleled opportunities for "engineering" previously inaccessible values of refractive indices and new ways for light manipulation. In this talk, we discuss a new class of graded-index metamaterials, transition metamaterials, whose effective dielectric permittivity and magnetic permeability gradually change from positive to negative values. These materials reveal several peculiar optical phenomena, including anomalous electromagnetic field enhancement and resonant absorption, thus opening new opportunities for linear and especially nonlinear optical applications.

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MS23

Excited States of the Gross-Pitaevskii Equation with a Harmonic Potential in the Thomas-Fermi Limit

Excited states of Bose-Einstein condensates are considered in the semi-classical (Thomas-Fermi) limit of the Gross–Pitaevskii equation with repulsive inter-atomic interactions and a harmonic potential. The relative dynamics of dark solitons (density dips on the localized condensate) with respect to the harmonic potential and to each other is approximated using the averaged Lagrangian method and the method of Lyapunov-Schmidt reductions. This permits a complete characterization of the equilibrium positions of the dark solitons as a function of the chemical potential parameter. It also yields an analytical handle on the oscillation frequencies of dark solitons around such equilibria. The asymptotic predictions are generalized for an arbitrary number of dark solitons and are corroborated by numerical computations for 2- and 3-soliton configurations. This is a joint work with M. Coles and P. Kevrekidis.

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MS23

On the Blow up Behavior of Solutions to the Focusing Schrodinger Equation

We review the global behavior of solutions to the 3d focusing (cubic) nonlinear Schrödinger equation with finite energy initial data and discuss blow up criteria as well as various dynamics of blow up solutions.

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MS24

Near Soliton Evolution in 2-d Schrödinger Maps

We consider the Schrödinger Map equation in $2+1$ dimensions, with values into $\S^2$. This admits a lowest energy steady state Q, namely the stereographic projection, which extends to a two dimensional family of steady states by scaling and rotation. We prove that Q is unstable in the energy space $\dot{H}^1$. However, to achieve this we show that within the equivariant class Q is stable in a stronger topology $X \subset \dot{H}^1$. This is joint work with Daniel Tataru.

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MS24

Concentration Compactness for Wave Maps

We will discuss a recent adaptation of the concentration compactness method for critical nonlinear waves due to Bahouri Gerard and Kenig Merle to the context of critical wave maps with hyperbolic target. This is joint work with W. Schlag.

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MS24

Long-time Existence for Quasilinear Wave Equations in Exterior Domains

We shall explore some new long time existence results for quasilinear wave equations with small initial data in exterior domains. In particular, we focus on results where the nonlinearity is permitted to depend on the solution not just its derivatives.

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MS24

Well-posedness and Invariant Measure for the Stochastic KdV-Burgers Equation

In this talk, we consider the periodic stochastic KdV-Burgers equation (SKdVB) with additive noise. The noise is white is time. However, it is a derivative of the white noise in space. First, we establish local well-posedness via the Fourier restriction method by discussing how to treat the rough noise. By establishing an a priori bound on the L^2 norm (when the noise is controlled to be in L^2 in space), we extend local-in-time solution to global ones. Lastly, we show that the (spatial) white noise is invariant under the flow (for the non-smoothed noise.) This involves in applying Bourgain's idea on invariant measures for deterministic PDEs to stochastinc PDEs. This is a joint work with J. Quastel and G. Richards.

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MS25

Stability of Transition Waves in Cahn-Hilliard Equations and Systems

I'll discuss stability of transition waves for the Cahn-Hilliard equation on $\mathbf{R}^n$ and for Cahn-Hilliard systems on $\mathbf{R}$. In the case of Cahn-Hilliard equations, the underlying Hamiltonian structure allows for a relatively straightforward spectral analysis, and we find that transition waves are spectrally stable under quite general circumstances. Pointwise semigroup methods can then be applied to establish that spectral stability implies nonlinear stability. I will review these results and discuss recent progress in the case of systems.

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MS25

Coherent Structures in Recurrent Precipitation

We discuss propagation into unstable states in a simple, yet surprisingly rich, 2-species reaction diffusion system that arises as a model for recurrent precipitation and for solidification in undercooled liquids. We show that the invasion of unstable states can create homogeneous bulk states or transient periodic patterns. Transitions between different invasion regimes can be interpreted as heteroclinic bifurcations. The results are a crucial building block for a conceptual understanding of Liesegang pattern formation.

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MS25

Conditional Stability of Special Solutions of the Klein-Gordon Equation

We explicitly construct the center-stable manifold for the steady state solutions of the Klein-Gordon equation, including the one dimensional equation. The main difficulty in the one-dimensional case is that the required decay of the Klein-Gordon semigroup does not follow from Strichartz estimate alone. In this talk, I will explain how to resolve this issue by proving an additional weighted decay estimate, which will allow us to close the argument.

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MS25

Stationary Radial Spots in a Planar Three-component Reaction-diffusion System

In this presentation, we analyze the existence and stability of stationary radial spots of a planar three-component system of FitzHugh-Nagumo type. In particular, we report on results on the most unstable eigenvalues that decide through which type of instability the stationary structures become unstable. Numerical simulations suggest that the third component is necessary to stabilize traveling spot solutions as these solutions are unstable for its two-component analogue.

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MS26

Compaction-dissolution Waves in Magma Dynamics

Viscous deformation of the solid matrix coupled to reactive porous flow of the buoyant melt in the interior of the Earth gives rise to a rich set of instabilities. We present a stability analysis and high resolution simulations. A regime diagram identifies four dynamic regimes: high-porosity channels form; compaction-dissolution waves form; both channels and waves form; system is stable. This wave instability leads to a migrating checkerboard pattern in the porosity, and depletion of the soluble material along nodal lines, and may offer an alternative explanation for observed depletion patterns.

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MS26

Melting and Two-phase Flow in the Earth and Planets

This presentation reviews the influence of melt nanostructure on migration, storage, and evolution of magma in the deep interior of the Earth and other planets. Structure of intergranular contact controls the average surface tension, melt mobility, and effective elastic properties. In the planetary scale, such changes influence rate of magma transport, location of magma storage, seismic signature of melt reservoir, and tidal dissipation in eccentric satellites.

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MS26

Stress-driven Organization of Melt and Strain in Deforming Partially Molten Rocks: A Synthesis of Observations

We present experimental observations of deforming viscous granular material (rocks) with small but interconnected melt fractions, in which melt organizes to form networks of shear zones (waves of enhanced strain and melt). These networks reduce effective viscosity and energy dissipation under a variety of boundary conditions. We constrain kinetics by tracking time-space evolution of pattern formation. Two-phase flow theory requires nonlinearities in the constitutive relation (in stress, melt fraction and anisotropy) to fit observed patterns.

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MS26

Rigorous Results on Model Equations for Magma Migration

An outstanding problem in Earth science is to understand the migration of magma in the Earths interior. One proposed method is the percolation of the melt through the porous rock. We survey models for the transport of melt through this viscously deformable porous medium. Furthermore, we present results on existence, uniqueness, and stability for reduced versions of these systems, which are dispersive, nonlinear wave equations. This work is joint with Marc Spiegelman and Michael I. Weinstein.

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MS27

Collapse and Light Bullets in the Few-cycle Regime

Few-cycle pulse propagation in a two level medium is considered in the two limits of low and high resonance frequency. Two different (2+1)-dimensional models of generalized Kadmotsev-Petviashvili and sine-Gordon type are derived and studied. In one case collapse is evidenced, in the other case light bullets form.

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MS27

Modeling Photon Generators and Frequency Convertors

Abstract not available at time of publication.

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MS27

Pedestal-Free Pulse Compression in Nonlinear Fibers and Nonlinear Fiber Bragg Gratings

We studied theoretically pedestal-free optical pulse compression using self-similar chirped optical solitons in nonlinear optical fibers and near the photonic bandgap structure of Fiber Bragg gratings with exponentially decreasing dispersion. In addition to compression of self-similar fundamental solitons, we also studied optical pulse compression using higher order chirped solitons using the Bäcklund transformation method. The special chirped soliton breathers can achieve both the high degree compression and high quality compression.

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MS27

Two-dimensional Mode-locking in Planar Waveguide Arrays

A theoretical proposal is presented for the generation of mode-locked light-bullets in planar waveguide arrays, extending the concept of time-domain mode-locking in waveguide arrays to spatial mode-locking in slab waveguides. The model presented yields three-dimensional localized states that act as global attractors to the waveguide array system. Single-bullet stationary and time-periodic solutions are observed to be stabilized in this system. The transition from single bullet to multiple bullet solutions is also studied.

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MS28

Shape Optimization of Helical Propellers for Low Reynolds Number Propulsion

Certain bacterial species utilize helical flagella for propulsion in low Reynolds number environments. Recent experiments replicating this locomotion strategy use magnetic fields to rotate colloidal helices. We investigate the dependence of the performance and efficiency of such micro-swimmers on their geometry, via shape optimization on helical bodies. We identify geometries that maximize rotation-translation coupling and efficiency. From this, we may draw conclusions regarding the performance of bacterial flagella and provide insights into effective micro-swimmer design.

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MS28

A Second Order Virtual Node Algorithm for Poisson Interface Problems

Abstract not available at time of publication.

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MS28

Dynamics and Transport of Nano-shuttle and Nano-motors

Bio-polymers such as actin filaments or microtubules are important in many cell functions. Through interactions with molecular motors, the chemical energy of ATP (adenosine triphosphate) hydrolysis is converted to mechanical work and the biopolymers can move or transport materials in the cells. In vitro motility assays have been used to characterize the dynamics of the biopolymers and the molecular motors that drive the motions. These results have been utilized for nano-cargo transport in cellular size synthetic devices. In this talk we present a continuum slender-body model for such bio-polymers immersed in viscous fluid. We will show that this model gives reasonable agreement with the experiments. Simulations also show novel wave dynamics of these bio-polymers in different forcing landscape.

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MS28
Algorithms for Simulating Vesicle Flows

Vesicles are locally-inextensible fluid membranes that can sustain bending. We consider the dynamics of flows of vesicles suspended in Stokesian fluids. We use a boundary integral formulation for the fluid that results in a set of nonlinear integro-differential equations for the vesicle dynamics. The motion of the vesicles is determined by balancing the nonlocal hydrodynamic forces with the elastic forces due to bending and tension. Numerical simulations of such vesicle motions are quite challenging. On one hand, explicit time-stepping schemes suffer from a severe stability constraint due to the stiffness related to high-order spatial derivatives and a milder constraint due to a transport-like stability condition. On the other hand, an implicit scheme can be expensive because it requires the solution of a set of nonlinear equations at each time step. We present a set of numerical techniques for efficient simulation of vesicle flows. The distinctive features of these numerical methods include using boundary integral method accelerated with fast multipole method, spectral (spherical harmonic) discretization of deforming surfaces in space, and a careful choice of semi-implicit time-stepping scheme. We demonstrate numerical schemes that experimentally are unconditionally stable, and have low cost per time step.

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MS29
Numerical Studies of Breaking in the Semiclassical Solution of the Focusing Nonlinear Schrödinger Equation

I will discuss parametric dependence of Riemann-Hilbert problems in connection with focusing NLS. The result is based on numerical observations and it is obtained in an abstract setup of Riemann-Hilbert problems. This is joint work with A.Tovbis and S.Venakides.

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MS29
Parametrices of Riemann-Hilbert Problems When They Do Not Exist: Painlevé I and the Shape of the First Spike at the Gradient Catastrophe of NLS

The talk will delve in the construction of the proper parametrix for the analysis of the NLS near the point of gradient catastrophe (following up the talk by A. Tovbis in the same minisimposium). In particular we are faced with the unusual problem of constructing and alternative parametrix in a neighbourhood of the points in the parameter space where the usual solution to the relevant RHP is known to not exist. The solution of this problem relies upon modifying the Riemann Hilbert problem for the Lax matrix of the Painlevé I equation.

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MS29
Semiclassical Focusing NLS with Square Barrier Initial Data

In this paper we present results on the small dispersion limit of the focusing nonlinear Schrödinger equation for step initial data. Using Riemann-Hilbert techniques we derive rigorous pointwise asymptotics for the solution globally in space and for times less then a $\mathcal{O}(\infty)$ maximal time. In particular we observe that each discontinuity is regularized by the immediate onset of genus-one oscillations in a growing region of space time emanating from each discontinuity. To leading order these oscillations are described by a slowly modulated one phase wave whose evolution is given by the corresponding Whitham equations.

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MS29
Universality of Gradient Catastrophe Approximation for the Semiclassical Focusing NLS, or how to see the Poles of the Tritronquee Solution of P-I.

We present a complete description of the nondegenerate point of gradient catastrophe for the semiclassical limit of the focusing Nonlinear Schrödinger equation (NLS), which include both the oscillatory and the nonoscillatoty parts of a vicinity of the gradient catastrophe point. In particular, we prove that: i) there is a one to one correspondence between the spikes in the oscillatory part and the poles of the special tritronquée solution of the Painleve I (P1); ii) the height of each spike is (asymptotically) **3** times the absolute value of the backgrond; iii) Each spike has the **universal shape** of the (scaled) **rational breather solution to the NLS**; iv) all error estimates expressed in terms of the tritronquée solution. All results were obtained through the nonlinear steepest descent method for Riemann-Hilbert problems and discrete Schlesinger transformations. There seem to be an interesting connection with "rogue" waves theory.

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MS30

A Hybrid Waveplate Model for the Description of Polarization-mode Dispersion in Installed Optical Fiber Transmission Systems

I will present a new mathematical model for polarization-mode dispersion (PMD) in installed optical fiber transmission systems. The model is a generalization of various variants of the so-called hinge model of PMD, and it reduces to these variants in appropriate limits. I will then describe an adaptive variance reduction technique that combines importance sampling and the cross-entropy method and that can be used to assess PMD-induced transmission impairments in this model.

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MS30

Capacity Limits of Fiber Optics Communication Systems

Determining the maximum quantity of information that can be transported over optical fibers is a very challenging problem of both fundamental and practical interests. An important challenge in establishing a "fiber capacity' originates from the difficulty of dealing with fiber propagation governed by the stochastic nonlinear Schrödinger equation. In this symposium, we will describe an approach we developed to calculate a capacity estimate of "fiber channels' and present capacity estimates results. We will also discuss the physical origins of capacity limitations.

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MS30

Resolving the Raman-induced Cross-frequency Shift in Soliton Collisions

Raman-induced frequency-shift in optical pulse collisions (Raman cross frequency-shift) is a nonlinear process that plays an important role in the dynamics of ultra-short optical pulses. We present the results of high-resolution numerical simulations, which enable an accurate measurement of the Raman cross frequency-shift in soliton collisions. The measurements are based on a fine frequency grid, with frequency spacing as low as 10^{-3}. The results of the simulations are compared with approximate analytic predictions.

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MS30

A Lie-Transform Based Idea to Treat Weakly Stochastic Hamiltonian Systems

Weakly stochastic Hamiltonian systems arise naturally in the context of fiber optics and soliton dynamics. The noise interacts with the deterministic trajectories in a highly complicated way and it is, in general, difficult to develop a systematic perturbation expansion due to operator asymmetry in the associated Fokker-Planck equation. The purpose of this talk is to introduce entirely new idea based on Lie transforms to treat such systems.

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MS31

A Boundary Integral Method for the Irrotational Water Wave

We present a boundary integral method for the efficient computation of 2D irrotational water waves. The fluid domain considered is of finite depth, with a variable bottom. The height of the free surface, as well as the height of the fixed bottom, can be multi-valued. Results of the simulations will be shown.

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MS31

Absorbing Boundaries for 2D Free Surface Flow

The evolution of water waves has long been modeled using nonlinear potential flow. In [S. Wu, Well-posedness in Sobolev spaces of the full water wave problem in 2-D, Invent. Math, 130 (1997), pp. 39-72], S. Wu proved the well-posedness of the two-dimensional water wave problem, and formulated a PDE that is equivalent to the incompressible irrotational Euler system. To leading order, the equation reduces to a linear nonlocal wave-like scalar PDE involving the Hilbert transform. We are concerned with numerical solutions for water wave problems in unbounded domains, using this new formulation of the water wave equation. The computational domain is truncated to a finite size, and boundary conditions are required to make the domain boundaries transparent. An idea that has proven successful with other wave-like equations is to modify the equation in a region near the outer boundary in order to absorb outgoing waves without generating reflections. In this talk, we will give an overview of the new formulation, introduce a one way version of the water wave equation, and incorporate wave damping. We will present numerical approaches to solving the equation in both Fourier and physical space. Numerical examples will be shown.

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MS31

An Efficient Boundary Integral Method for 3D Interfacial Flow with Surface Tension

An efficient, non-stiff boundary integral method for 3D porous media flow with surface tension is presented. Surface tension introduces high order (i.e., high derivative) terms into the evolution equations, which leads to severe stability constraints for explicit time-integration methods. Furthermore, the high order terms appear in nonlocal operators, making the application of implicit methods difficult. Our algorithm employs a special representation of the interface which enables efficient application of implicit time-integration methods via a small-scale decomposition. The algorithm is found to be effective at eliminating the severe time-step constraint that plagues explicit time-integration methods.

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MS31

Computation of Time-periodic Water Waves

I will describe a spectrally accurate method for computing time-periodic water waves of finite or infinite depth. We use adjoint methods to minimize a functional (of the initial condition and period) that is positive unless the solution is periodic, in which case it is zero. We find solutions of the true water wave resembling multi-phase cnoidal solutions of KdV and observe interesting disconnections in the bifurcation diagrams due to nonlinear resonances at critical bifurcation parameters.

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MS32

Numerical Methods for Chemotaxis Models

In our work we propose a family of stable and highly accurate numerical methods, based on interior penalty discontinuous Galerkin schemes for the Keller-Segel chemotaxis model. We prove hp error estimates for the proposed schemes. Our proof is valid for pre-blow-up times since we assume some regularity of the exact solution. Numerical experiments to demonstrate the stability and high accuracy of the proposed methods for chemotaxis models and comparison with other methods will be presented.

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MS32

Three Wave Interaction in Negative Index Metamaterials

Three wave interaction in negative index material takes place in the presence of contra-propagating waves, which results from opposite directionality of wave and Poynting vectors. We studied parametric amplification and second harmonic generation in the presence of material losses and detuning from resonance phase matching condition. Theoretical study is verified by direct numerical simulations.

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MS32

Effective Dynamics of Double Solitons for Perturbed mKdV

We show that an interacting double soliton solution to the perturbed mKdV equation is close in $H2$ to a double soliton following the effective dynamics obtained as Hamilton's equations for the restriction of the mKdV Hamiltonian to the submanifold of solitons. The interplay between algebraic aspects of complete integrability of the unperturbed equation and the analytic ideas related to soliton stability is central in the proof.

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MS32

Dissipative Effects in Positive-negative Index Coupler

The intriguing example of the negative-positive refraction

medium is the coupler, where one of the waveguides is fabricated from a material with a negative refractive index. This device acts as a (distributed) mirror. The radiation entering one waveguide leaves the device through the other waveguide at the same end but in the opposite direction. The opposite directionality of the phase velocity and the energy flow in this channel results in the gap soliton formation in a uniform nonlinear coupler without periodicity or feedback mechanism. The corresponding analytical solution is found and it is used for numerical simulation to illustrate that the results of the solitary wave collisions are sensible to the relative velocity of the colliding solitary waves.

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MS33
Well-posedness for Gauged Schrodinger Equations

We discuss conditions on the gauge potential under which we can have a blowup or global existence and scattering. We show applications to some physical systems.

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MS33
Numerical Simulation of Resonant Tunneling for Cubic Schrodinger Equation

In this work, we show numerically the phenomenon of resonant tunneling for fast solitons through large potential barriers for the cubic Nonlinear Schrödinger equation in one dimension with external potential. Resonant tunneling is well known in linear scattering theory and refers to a situation where the reflection coefficient vanishes at certain energies of incoming waves.We consider two classes of potentials, namely the 'box' potential and a repulsive 2-delta potential under certain conditions. We show that the transmitted wave is close to a soliton, calculate the transmitted mass of the solution and show that it converges to the total mass of the solution as the velocity is increased.

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MS33
Weak Interactions Between Fronts in LDE

In order to better understand interactions between fronts in lattice differential equations, we construct solutions which are roughly the superposition of two well-separated fronts. In particular, we construct a two-dimensional manifold of such solutions (the two parameters should be thought of as the location of each of the fronts) and show that this manifold is dynamically stable. In particular, we discuss how our methods, initially developed for reaction-diffusion PDE, carry over to lattice systems. This work is joint with Aaron Hoffman.

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MS34
Supercritical Fronts for Reaction-diffusion Equations in Infinite Cylinders

In this talk I will present some recent results concerning the analysis of fronts invading into unstable equilibrium in infinite cylinders. It will be shown that supercritical fronts of invasion can be viewed as critical points of certain functional which allows to use machinery of calculus of variations. Consequently, the study of superctitical fronts can be performed in a rather general framework with no structural assumptions on nonlinearity apart from minimal regularity requirements. This is a joint work with C.B. Muratov and M. Novaga

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MS34
Linear Stability for Solutions to the Vortex Filament Equation

In its simplest form, the self-induced dynamics of a vortex filament in a perfect fluid is governed by the Vortex Filament Equation (VFE), which is related to the Nonlinear Schrödinger (NLS) equation via the Hasimoto map. The NLS is integrable and admits a corresponding AKNS linear system. We show how the squared eigenfunctions of the AKNS system and the Hasimoto map can be used to construct solutions of the linearized VFE and obtain stability properties of vortex filaments.

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MS34
On the Traveling Waves in the Gray-Scott Model

For a wide range of parameter values we show the existence of rich families of traveling wave solutions of the Gray-Scott model. We find pulse solutions, periodic wave trains, families of fronts that connect constant states, constant states to a periodic wave train, two periodic wave trains. In certain singular limits, by using rescaled versions of the equations, we pinpoint the structure of the traveling waves. The results are anchored in geometric singular perturbation theory.

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MS34

Infinite Dimensional Evans Function and the Stability Index

In this talk, an over view is presented for a topological frame work defined for eigenvalue problems of elliptic operators. This theory is an infinite dimensional generalization of that of the classical Sturm-Liouvill theory to non self-adjoint operators. Starting from the classical one, how the theory is generalized to non self-adjoint problems and to infinite dimensional setting will be explained.

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MS35

Bifurcations and Stability of Boundstates in NLS via Reduced Equations

The talk will focus on the existence and orbital stability of periodic in time, localized in space solutions (boundstates) of nonlinear Schrödinger equations. I will discuss recently obtained necessary and sufficient conditions for the existence of bifurcation points along branches of boundstates, then I will classify the possible bifurcations and their effect on stability of the branches via reduced equations. The results were obtained in collaboration with D. Pelinovski (McMaster), P. Kevrekidis (UMass) and V. Natarajan (UIUC).

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MS35

Long Time Dynamics Near the Symmetry Breaking Bifurcation for Nonlinear Schrödinger/Gross-Pitaevskii Equations

We consider a class nonlinear Schrödinger / Gross-Pitaevskii equations (NLS/GP) with a focusing (attractive) nonlinear potential and symmetric double well linear potential. NLS/GP plays a central role in the modeling of nonlinear optical and mean-field quantum many-body phenomena. It is known that there is a critical L^2 norm (optical power / particle number) at which there is a symmetry breaking bifurcation of the ground state. We study the rich dynamical behavior near the symmetry breaking point. The source of this behavior in the full Hamiltonian PDE is related to the dynamics of a finite-dimensional Hamiltonian reduction. We derive this reduction, analyze a part of its phase space and prove a *shadowing theorem* on the persistence of solutions, with oscillating mass-transport between wells, on very long, but finite, time scales within the full NLS/GP. The infinite time dynamics for NLS/GP are expected to depart, from the finite dimensional reduction, due to resonant coupling of discrete and continuum / radiation modes.

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MS35

Traveling Waves in Thermally Driven Optical Parametric Oscillators

The mean-field behavior of detuned optical parametric oscillators subject to absorption-induced heating can be described using a parametrically forced scalar nonlinear Schrödinger equation, which is shown to support tightly bound asymmetric traveling waves in addition to weakly bound 'multipole-mode' solutions. We discuss the existence and stability of these traveling waves in the scalar equation and in the mean-field system from which it is derived.

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MS35

Transitional Dynamics in the Reduced Model of a Mode-locking Waveguide Array

Recent studies on mode-locking in waveguide arrays have shown that an increase in gain can transition the system from N- to $N+1$-pulse solution through a chaotic process initiated by a Hopf bifurcation. This transition is analyzed by projecting the governing PDEs onto finite set of orthogonal modes that capture most of the energy in the system. Bifurcation diagrams of the reduced model reveal a sequence of period-doubling bifurcations, identifying the mechanism responsible for the onset of chaos.

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MS36

Continuation of Solutions of the Nonlinear Schrodinger Equation Beyond the Singularity

The continuation of NLS solutions beyond the singularity has been an open problem for many years. In this talk I will present several novel approaches to this problem, and discuss their consequences.

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MS36

Predicting the Filamentation of High-power Beams and Pulses without Numerical Integration: A Nonlinear Geometrical Optics Method

We present an analytic method for predicting the initial self-focusing dynamics of high-power beams and pulses. Using this method we study the filamentation pattern of a variety of input profiles in 1D, 2D and 3D, without solving partial differential equations. In particular, this method explains why super-Gaussian initial conditions lead to ring-type blowup of NLS solutions and predicts a new type of temporal splitting.

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MS36

Cascaded Four-wave Mixing and Spatial Supercontinuua

We experimentally and numerically study nonlinear light propagation in a fractal waveguide array. We consider a nested set of periodic arrays and examine energy transport as a function of band structure, nonlinearity, and probe beam geometry. Experimentally, we observe the behavior directly in position and momentum spaces. The results are fundamental to nonlinear wave dynamics in self-similar structures and hold potential to improve the efficiency and sensitivity of fractal photonic devices.

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MS36

Condensation of Random Classical Waves

he nonlinear propagation of random fields can be described by thermodynamic arguments. For quantum fields, a major consequence is (Bose-Einstein) condensation, in which the ground state is macroscopically occupied. Here, we show using wave turbulence theory that classical fields can also condense, with thermalization manifesting itself by means of an irreversible evolution towards the state of maximum disorder. The theory is confirmed by observing the condensation of classical optical waves in a self-defocusing photorefractive crystal.

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MS37

Title Not Available At Time of Publication

Abstract not available at time of publication.

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MS37

Simulation of Tumor Growth - Free Boundary Problems using Octrees

Simulation of biological processes often require the solution of partial differential equations (PDEs) on large data set. I will present a novel paradigm for solving PDEs on octree data structures. Second-order accuracy is achieved for several classes of relevant PDEs.

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MS37

Shivers, Blisters and Waves in Eukaryotic Cilia and Flagella

The undulating motions of eukaryotic flagella and cilia produce forces that cause locomotion. While it is known that these oscillations (bending waves) form as a result of the coupling between the filament backbone (geometry and mechanics) and active forces due to molecular motors (kinetics), the mechanisms that result in sustained oscillations are unclear and are still intensely researched. I will describe a minimal model for the onset and propagation of motor driven bending waves that is motivated by recent experimental results. Equations that describe the evolution of the force generating active motors are coupled to filament configuration and elasticity. Appropriate ensemble averaged force-velocity relationships for the motors completes the set of equations. These equations allow us to understand and interpret three types of flagellar motions - 1) shivers - localized shape perturbations that decay in time and space, 2) blisters - a single pronounced bump that travels along the filament and 3) waves - sustained bending oscillations that emerge under favorable conditions.

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MS37

An Integrated Model of Microtubule-based Pronuclear Motion in the Single-celled *C. Elegans* Embryo

We present an integrated model of microtubule-based pronuclear motion in the single-celled *C. elegans* embryo. This theoretical model determines how the male pronucleus is transported through the single-celled embryo in the early stages of development. In this model, centrosomes initiate stochastic microtubule growth and these microtubules interact with motor proteins distributed in the cytoplasm. Consequent pulling forces drag the pronucleus through the cytoplasm, here modeled as a viscous incompressible Newtonian fluid whose motions are constrained by contact with the cell periphery. The cell periphery also limits microtubule growth. Our computational method is based on an immersed boundary formulation which allows for the simultaneous treatment of fluid flow and the dynamics of structures immersed within. We find that the constraining geometry of the shell has a large effect on the microtubule forces necessary to move the pronucleus on experimentally observed time-scales, being an order of magnitude larger than those estimated in previous studies that do not take the effect of the shell into account when computing cytoplasmic motions. Our simulations shows pronuclear migration, and moreover, a pronuclear centration and rotation very similar to that observed *in vivo*.

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MS38

Stability of Periodic Solutions of Nonlinear Dispersive Equations

We present a theorem relating the number of potential instabilities of a periodic KdV travelling wave to the Hessian of the classical action governing the travelling wave ordinary differential equation. In the case of a polynomial nonlinearity this can be further simplified using the fact that the action is a hyperelliptic function and satisfies a Picard-Fuchs relation.

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MS38

Semiclassical Analysis of the Modified Nonlinear Schrodinger Equation

The Modified nonlinear Schrödinger equation (MNLS) exhibits both modulationally stable and unstable behavior for different initial conditions. In this talk we will investigate the semi-classical asymptotics for a family of initial conditions that contains both functions for which the stability condition is satisfied as well as functions for which it fails. We will use steepest descent techniques for oscillatory Riemann-Hilbert problems to obtain asymptotics for the solutions to the MNLS with these initial conditions.

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MS38

Chords and Solitons: The KP Solitons Revisited

I will present a brief summary of the recent development of classification theorem of the KP solitons [Chakravarty and Kodama, 2008-9]. The theorem shows that each soliton solution can be parametrized by a unique chord diagram representing a derangement of the permutation group. In view of the theorem, I will study several real waves observed in shallow water, and show that the KP equation provides an excellent model equation to describe resonant phenomena for those shallow water waves. I will also discuss the differences of KP solitons from the waves in real experiments.

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MS38

Random Normal Matrices via Riemann-Hilbert Analysis

Random hermitian matrix model has been studied quite successfully by applying the steepest descent analysis of the corresponding Riemann-Hilbert problem. We show that the same technique can be applied to random normal matrix model. This model is equivalent to certain weighted Bergman polynomials. We perform the asymptotic analysis on that polynomial. We consider a special case as an example. This is a joint work with Ferenc Balogh, Marco Bertola and Ken McLaughlin.

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MS39

Diffusive Transport in Two-dimensional Nematics

The spatially-extended Onsager-Maier-Saupe model of nematic liquid crystals is a variational model in which the free energy is a functional of a spatially-dependent probability density of orientations. I will discuss the diffusive transport dynamics associated with this model (Doi kinetic equation) and will derive equations governing the evolution of vortex-like patterns in the high concentration (long rods) limit of the two-dimensional model.

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MS39

Dielectrophoretic Assembly of Nematic Structures in Dispersions of Metal Nanorods

The greatest challenge in the development of nanoscale-structured metamaterials is to achieve the required spatial arrangement of elements and to switch these arrangements whenever necessary. We demonstrate experimentally an approach to construct a metamaterial in which metallic nanorods, of dimension much smaller than the wavelength of light, are suspended in a fluid and placed in a nonuniform electric field. The field controls the spatial distribution and orientation of nanorods because of the dielectrophoretic effect. The field-controlled placement of nanorods causes optical effects such as varying refractive index and optical anisotropy (birefringence).

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MS39

Some Recent Results on the Smoluchowski Equation Arising in the Modeling of Nematic Liquid Crystals

The talk will address two recent results concerning the Smoluchowski equation and the Onsager model for nematic liquid crystals. The first result concerns the existence of inertial manifolds for the Smloluchowski equation both on the circle and on the sphere. Inertial manifolds is a concept developed in the context of parabolic dissipative PDEs, which, when they exist, allows to in a sense view the PDE as a finite-dimensional dynamical system. The second result concerns the isotropic-nematic phase transition for the Onsager model using more complicated potentials than the Maier-Saupe potential.

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MS39

Phases and Flow Behavior of Biaxial Liquid Crystals

Abstract not available at time of publication.

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MS40

Periodic Solutions of the Serre Equations

The Serre equations are a model for the evolution of surface waves on an incompressible, irrotational, inviscid, shallow fluid. These equations admit a four-parameter family of periodic solutions and a three-parameter family of solitary wave solutions. We numerically study the linear stability of these solutions and present a parameter-dependent stability cut-off. Further, we asymptotically solve the wave shoaling problem in the slowly-sloping bathymetry limit.

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MS40

An Asymptotic Expansion for Solitary Gravity-capillary Waves

In this talk, we present high-order asymptotic series for one dimensional gravity-capillary solitary waves; the first term in the asymptotic series is the well-known $sech^2$ solution of the KdV equation. The series is used (with nine terms included) to investigate how small surface tension affects the height and energy of large amplitude waves, and waves close to the solitary version of the Stokes' extreme wave. In particular, for small surface tension, the solitary wave with the maximum energy is obtained. For large surface tension, the series is also used to study the energy of depression solitary waves. Energy considerations suggest that, for large enough surface tension, there are solitary waves that can get close to the fluid bottom.

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MS40

Rogue Waves, Dissipation and Downshifting

Damping plays an important role in stability and downshifting of waves. The physical and statistical properties of rogue waves in deep water are investigated using the focusing Nonlinear Schrödinger equation and the Dysthe equation with an additional damping term. The effects of both linear and nonlinear damping on the development of rogue waves and the interaction between rogue waves and downshifting are examined using numerical investigations and analytical arguments based on the inverse spectral theory of the underlying integrable model, perturbation analysis, and statistical methods.

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MS41

Solitary Waves in Non-dispersive Periodic Media

Solitary waves generally arise through a balance of dispersion and nonlinearity. A special kind of solitary waves have been discovered that arise in non-dispersive piecewise-homogeneous periodic elastic materials. These waves, dubbed stegotons, owe their existence to an effective dispersion resulting from material heterogeneity. In fact, such waves may arise quite generally in first-order hyperbolic

systems with periodically varying (in space) coefficients. We show through computational examples the diversity of situations that can lead to such waves. We also present analytical and computational results that quantify the conditions leading to stegoton-like waves. Finally, we discuss an interesting connection of these waves to the K(2,2) compacton equation.

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MS41

Nonlinear, Nonlocal, Degenerate, and Dispersive - What More Could You Ask For?

The magma equations are a family nonlinear, nonlocal, degenerate, dispersive wave equations that arise from models of magma migration in the Earth's interior. It is conjectured that for the physically meaningful range of nonlinearities, the equations do not develop finite time singularities. In this talk, we present cases for which we can prove global well-posedness. We then discuss the challenges of other cases, particularly for dimensions greater than one. This work is joint with Marc Spiegelman and Michael I. Weinstein.

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MS41

Compactons, Solitary Waves between Solitons and Localized Blow-up Solutions

Compactons are solitary waves with compact support appearing in evolution equations with nonlinear dispersion. A comparison of solitons of the Korteweg-de Vries equation and compactons of the Rosenau-Hyman K(2,2) equation is presented based on a phase plane analysis. The relation between compactons of the K(2,2) and the localized blow-up solutions of nonlinear reaction-diffusion combustion models is presented. Shock waves, rarefaction waves and blowup solutions of the K(2,2) are also discussed. The consequence of these solutions on the numerical analysis of evolution equations with compactons is emphasized, including the apperance of numerically-induced phenomena.

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MS41

Analytical Results for Equations with Nonlinear Dispersion

At this time, there is little existence theory for equations in which the mechanism which generates dispersion is itself nonlinear. In this talk, I will present a new equations which possesses compactly supported traveling waves (a hallmark of degenerate dispersive equations) and for which the Cauchy problem has a weak solution. This work is joint with D. Ambrose.

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MS42

Singularities and Asymptotics for Some Dynamics of Maps into the Sphere

I will describe results on singularity (non-)formation and stability, in the energy-critical 2D setting, for some nonlinear Schroedinger-type systems of geometric origin – the Schroedinger map and Landau-Lifshitz equation – which model dynamics of ferromagnets and liquid crystals.

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MS42

Internal Modes of Discrete Solitons Near the Anti-continuum Limit of the dNLS Equation

Discrete solitons of the discrete nonlinear Schrdinger (dNLS) equation become compactly supported in the anti-continuum limit of the zero coupling between lattice sites. Eigenvalues of the linearization of the dNLS equation at the discrete soliton determine its spectral and linearized stability. All unstable eigenvalues of the discrete solitons near the anti-continuum limit were characterized earlier for this model. We analyze the resolvent operator and prove that it is uniformly bounded in the neighbourhood of the continuous spectrum if the discrete soliton is simply connected in the anti-continuum limit. This result rules out existence of internal modes (neutrally stable eigenvalues of the discrete spectrum) of such discrete solitons near the anti-continuum limit.

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MS42

Near-linear Dynamics in KdV with Periodic Boundary Conditions

We show that the evolution of periodic (in space) high frequency solutions of the Korteweg de Vries equation is almost linear for large times.

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MS42

Solitary Waves for the Hartree Equation with a Slowly Varying Potential

We study the Hartree equation with a slowly varying smooth potential $V(x) = W(xh)$, and with an initial condition which is $\epsilon \leq \sqrt{h}$ away in H^1 from a soliton. We show that up to time $|\log h|/h$ and errors of size $\epsilon + h^2$ in H^1, the solution is a soliton evolving according to the classical dynamics of a natural effective Hamiltonian. This result is based on methods of Holmer-Zworski, who prove a similar theorem for the Gross-Pitaevskii equation, and on the spectral estimates for the linearized Hartree operator recently obtained by Lenzmann. We also provide an extension of the result of Holmer-Zworski to more general initial conditions.

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MS43

Stability of Waves in Liquid Films on Vibrating Substrates

We study thin liquid films on horizontally vibrating substrates. Using an equation derived by Shklyaev, Alabuzhev, and Khenner (Phys. Rev. E 79, 051603, 2009), we show that all periodic and solitary-wave solutions of this equation are unstable regardless of their parameters. This is a joint work with E.S. Benilov.

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MS43

The Stability of Finite-genus Solutions of Integrable Equations

The last few years we have been able to establish the orbital stability of the periodic finite-genus solutions of the KdV equation, as well as the stationary periodic solutions of the defocusing NLS equation and the MKdV equations. To accomplish this, we have been combining ideas from integrability with classical methods from dynamical systems involving the Krein signature and the classical work of Grillakis, Shatah and Strauss. In this talk I will outline how one can proceed to establish the orbital stability of the periodic finite-genus solutions of integrable equations which are characterized by a Lax pair whose first component is self adjoint.

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MS43

The Krein Signature, Krein Eigenvalues, and the Krein Oscillation Theorem

In this paper the problem of locating eigenvalues of negative Krein signature is considered for operators of the form $\mathcal{J}\mathcal{L}$, where $\mathcal{J}$ is skew-symmetric with bounded inverse and $\mathcal{L}$ is self-adjoint. A finite-dimensional matrix, hereafter referred to as the Krein matrix, is constructed with the property that if the Krein matrix has a nontrivial kernel for some z_0, then $\pm\sqrt{-z_0} \in \sigma(\mathcal{J}\mathcal{L})$. The eigenvalues of the Krein matrix, i.e., the Krein eigenvalues, are real meromorphic functions of the spectral parameter, and have the property that their derivative at a zero is directly related to the Krein signature of the eigenvalue. The Krein Oscillation Theorem relates the number of zeros of a Krein eigenvalue to the number of eigenvalues with negative Krein signature. Because the construction of the Krein matrix is functional analytic in nature, it can be used for eigenvalue problems posed in more than one space dimension.

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MS43

An Unexpected Geometric Interpretation of Krein Signature

Krein signature is an algebraic quantity that proved to be extremely helpful in spectral stability analysis. But convenience of its use is often complicated by inability to determine it from eigenvalue diagrams produced by numerical calculations. We demonstrate a case when the geometric interpretation of Krein signature unexpectedly appears in a class of nonlinear eigenvalue problems with applications in hydrodynamic stability or electric power systems. Our technique is based on a simple geometric intuition that suggests to reduce an analysis of a real part of the spectrum of a nonlinear eigenvalue problem to an analysis of spectra of an one-parameter family of linear operators without extending the dimension of the underlying space.

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MS44

Symmetry-breaking Bifurcation in the Gross-Pitaevskii Equation with a Double-well Potential

We classify bifurcations of the asymmetric states from a family of symmetric states in the focusing (attractive) Gross-Pitaevskii equation with a symmetric double-well potential. Depending on the shape of the potential, both supercritical and subcritical pitchfork bifurcations may occur. We also consider the limit of large energies and show that the asymmetric states always exist near a non-degenerate extremum of the symmetric potential. These states are stable (unstable) in the case of subcritical nonlinearity if the extremum is a minimum (a maximum). All states are unstable for large energy in the case of supercritical nonlinearity. This is a joint work with E. Kirr and P. Kevrekidis.

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MS44

Band Gaps, Localization and Solitons in Disordered Materials

In this talk I discuss spectral gaps in Schrödinger operators with potentials that are completely disordered (no delta-function peaks in Fourier space). Such gaps are counterintuitive since without periodicity, Bloch's theorem does not apply, and thus there is no "band splitting" mechanism for gap formation. Physically, these band gaps are exhibited in amorphous semiconductors and insulators. Here, I will present numerical and experimental results on an optical system that exhibits an amorphous gap, as well nonlinear

effects such as gap solitons in both two and three dimensions.

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MS44

Solitons, Defect Modes and Effective Mass

I will discuss the bifurcation of spatially localized defect modes into spectral gaps for the linear and nonlinear Schroedinger / Gross-Pitaevskii (NLS / GP) equations with a periodic potential. Our analysis uses a Lyapunov-Schmidt reduction based on a spectral localization "near to" and "far from" a spectral band edge. Effective mass (associated with the homogenized periodic structure) plays an important role in the dynamic stability of soliton-like states of NLS / GP. This talk is based on joint with B. Ilan and with M. Hoefer.

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MS44

Unified Description of Wave Envelope Dynamics in Simple Periodic Lattices

Wave envelope propagation in 2-D simple periodic nonlinear media is studied. A discrete approximation, known as the tight-binding approximation, is employed to find the linear dispersion relations and the governing equations of the discrete wave envelope dyanmics. A unified description of the dynamics is obtained for any input envelopes and for arbitrary 2-D simple periodic lattices. These governing equations are discrete evolution equations which are highly related to the linear dispersion relations. If the envelopes vary slowly in space,the continuous limits of these discrete equations are effective nonlinear Schrödinger equation. The coefficients of the dispersive terms are related to the second differentiation of the linear dispersion relations. The case that the dispersion relations are degenerate is also studied and the corresponding governing equations are coupled effective NLS equations.

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MS45

Self-induced Transparency Modelocking in Quantum Cascade Lasers

Standard (interband) semiconductor lasers operate in a limited wavelength range, below about 4 microns. Quantum cascade (intraband) semiconductor lasers (QCLs) that operate in the mid-IR and far-IR have important applications to medicine, environmental sensing, and national security. While short pulse intersubband semiconductor lasers ($\sim$ 100 fs) are available, that is not the case for QCLs. Standard passive modelocking is hard to do in QCLs because of their long coherence times and short gain recovery times. We propose a fundamentally different approach, based on the self-induced-transparency (SIT) effect, that turns these weaknesses into strengths. All passively modelocked lasers to date can be modeled using the nonlinear Schrödinger equation and its modifications; this new type of short-pulse laser must be modeled using the Maxwell-Bloch equations and their modifications.

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MS45

Amplifier Similaritons in a Fiber Laser

Amplifier similaritons are observed in a fiber laser. This constitutes a new pulse shaping mechanism with remarkable features: the parabolic pulse is a local attractor in a segment of the oscillator, the pulse evolution exhibits large spectral breathing, and the pulse chirp is less than the group-velocity dispersion of the cavity. In addition, a simple source generating parabolic pulses with high energies and the shortest pulses from a normal-dispersion laser will have use in applications.

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MS45

Dynamics of Few-cycle Ti:sapphire Lasers

We will present a one-dimensional laser model based on the Nonlinear Schroedinger Equation which accurately describes the pulse dynamics of few-cycle, dispersion-managed Ti:sapphire lasers. This allows us to predict the output spectrum and pulse shape in good agreement with experimental results. By extending this model, the carrier-envelope phase dynamics in these lasers are analyzed and the major contributions to the carrier-envelope phase shift quantitatively identified.

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MS45

High-energy Fiber Lasers based on Dissipative Solitons

Recent research has shown that it is possible to generate ultrashort pulses in a laser with only normal-dispersion components. Such a pulse balances amplitude modulation as well as the phase modulations, and so is a dissipative soliton. This approach allows systematic study of dissipative solitons, as well as simple and practical fiber lasers with unprecedented performance. Theoretical and experimental progress will be reviewed.

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MS46

The Einstein-Maxwell System in 3+1 Form and Initial Data for Multiple Charged Black Holes

In this talk I discuss the Einstein-Maxwell system as an initial value problem using the 3+1 formalism. I also focus on the problem of finding initial data for multiple charged black holes assuming time-symmetric initial data and using a puncture-like method to solve the Hamiltonian and Gauss constraints. I discuss the behavior of the resulting initial data families, and show that previous results in this direction can be obtained as particular cases.

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MS46

The Initial Data Problem for Magnetized Neutron Stars

While magnetic fields are ubiquitous features of stellar systems, it is only relatively recently that the evolution of compact objects such as neutron stars have been simulated using both general relativity and ideal magnetohydrodynamics. An important aspect of these simulations is beginning with physically reasonable initial data. To this end, we consider the problem of constructing equilibrium configurations of axisymmetric, polytropic stars with strong magnetic fields in general relativity.

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MS46

Compact Systems as Inducers of Waves in Electromagnetic and Gravitational Bands

Strongly gravitating systems can produce both gravitational and electromagnetic radiation. Detection and analysis of them would provide a unique way to study these systems and fundamentally advance our understanding of highly energetic phenomena and our cosmos. This talk will present results related to these system and discuss their implications.

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MS46

High Speed Black Hole Collisions

The class of spacetimes describing the merger of two black holes contain some of the most fascinating solutions to the equations of general relativity. In this talk I will review what has been learnt about the binary black hole problem over the past several years from numerical simulations of the Einstein field equations, focusing on the more "extreme" solutions obtained in the high velocity limit. This is of possible relevance to LHC and cosmic ray physics in certain proposed large extra dimension scenarios. Some of the interesting results include the near-Planck scale luminosity in radiated gravitational waves, recoil velocities of on the order of ten thousand kilometers per second or larger, zoom-whirl orbital motion, the formation of near-extremal Kerr black holes, and that in the ultra relativistic limit the internal nature of the colliding object, whether black holes or not, seemingly becomes irrelevant.

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MS46

Mathematical and Computational Challenges in Generating Templates for Gravitational Wave Detections

The generation of gravitational wave templates is critical for the detection of signals such as binary black hole collisions, among others. I will review the current status of numerical simulations of such scenarios, the mathematical and computational challenges, and some current work to address those challenges.

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MS47

The Semiclassical Limit of the Sine-Gordon Equation

The small-dispersion or semiclassical sine-Gordon equation is an integrable model of magnetic flux propagation in long Josephson junctions. While in principle the inverse-scattering method gives the exact solution for any well-posed initial data, in practice asymptotic analysis often yields the most useful information about the behavior of the solution. We first present a recent spectral confinement result, giving conditions when the spectrum of the system must lie in certain regions. Secondly, we discuss ongoing work on the asymptotic behavior of solutions near critical points where the qualitative behavior of the solution changes. Parts of this work are joint with Peter Miller.

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MS47

Caustics, Cluster Expansions and Counting Graphs

This talk will explore the structure of the large N (genus) expansion of the free energy for Hermetian random matrices. In particular, we will explain that the coefficients of these expansions are generating functions for the asymptotic (as the matrix size, N, grows) correlations of the Gibbs measures underlying the random matrix ensembles. The main result is that these generating functions are in fact fairly explicit rational functions of a distinguished algebraic function that is itself a geometric generating function. Moreover, in the double scaling limit of "2D quantum gravity" these coefficients limit, in a precise combinatorial sense, to the coefficients in the asymptotic expansions of solutions to the Paineleve I hierarchy. This result has significant applications to problems of recent interest in enumerative combinatorics.

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MS47

On Long-time Asymptotics for the KdV Equation

We will present recent results concerning the rigorous proof, via Riemann-Hilbert techniques, of the long-time asymptotics for the Korteweg deVries equation. We concentrate in particular on the asymptotics in the so-called collisionless-shock region, as well as on new techniques related to Riemann-Hilbert problems which arise during our derivation.

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MS47

Semiclassical Limit of the Scattering Transform for the Focusing NLS

The semiclassical limit of the focusing Nonlinear (cubic) Schrödinger Equation (NLS) corresponds to the singularly perturbed Zakharov Shabat (ZS) system that defines the direct and inverse scattering transforms (IST). We derive explicit expressions for the leading order terms of these transforms, which we call semiclassical limits of the direct and inverse scattering transforms. Thus, we establish an explicit connection between the decaying initial data of the form $q(x, 0) = A(x)e^{iS(x)}$ and the leading order term of its scattering data. This connection is expressed in terms of an integral transform that can be viewed as a complexified version of the Abel transform. Our technique is not based on the WKB analysys of the ZS system, but on the inversion of the modulation equations that solve the inverse scattering problem in the leading order. The results are illustrated by a number of examples.

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MS48

Evolution of Structures in Neuronal Networks with Plasticity

We consider neuronal network models with plasticity and randomness; we show that complicated global structures can evolve even in the presence of simple local update rules. Specifically, we propose a discrete-time stochastic model of the evolution of a layered neuronal network which is capable of learning through plasticity of the connections between layers. The structure of the network is thus modulated by the conductances of the connecting neurons, which evolve according a model mimicking long-term potentiation. We demonstrate that the network is capable of rich properties (e.g. bifurcation, various forms of stability, etc.) that depend on maximum possible values of conductance, the inputs to the network, and the number of levels in the integrate-and-fire output neuron model. We will also remark on the Lyapunov exponents and information-theoretic properties of such networks.

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MS48

Reliability of Coupled Oscillators

This talk concerns layered networks of coupled oscillators and the reliability of such networks. Reliability means that upon repeated presentations of a given stimulus, the network gives essentially the same response each time. I will present an analysis of how conditions within such layered networks affect their reliability. This is joint work with Eric Shea-Brown and Lai-Sang Young.

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MS48

Synchrony in Stochastic Pulse-coupled Neuronal Network Models

We investigate the interplay between fluctuations, which de-synchronize, and synaptic coupling through network connections, which synchronize model networks of integrate-and-fire neurons. By calculating the probability to remain synchronized, we explore the significance of the local network topology and of more physiological additions to the model on its ability to maintain synchrony. We calculate the random time between synchronous events in terms of a first-passage-time problem for a single neuron.

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MS48

Steps Towards Coarse Graining Neuronal Network Dynamics within an Intermittently Desupressed Regime

I will present some results relating to a simplified model of neuronal network dynamics which is specifically designed to capture some of the correlated activity observed in real neuronal networks (e.g., in mammalian visual cortex and/or insect antennal lobe).

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MS49

Title Not Available At Time of Publication

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MS49

Propagation of Large Amplitude Internal Waves over Bottom Topography

We are interested in the evolution of large amplitude internal waves in the ocean which is simplified to a two-layer fluid (inviscid, irrotational) with different constant densities. Recently, a regularized model for strongly nonlinear internal waves in a two-layer system has been proposed to eliminate the shear instability at the interface of the two layers. We include the effect of varying bottom topography and solve the time evolution equations numerically using a pseudo-spectral method along with a fourth order Runge-Kutta time integration. Numerical solutions will be presented for the interaction of large solitary waves with bottom topography.

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MS49

Simulations of Rogue Waves in Shallow Water

A series of numerical simulations considering the action of wind on steep waves and breaking waves generated through the mechanism of dispersive focusing on finite depth is performed. The dynamics of the wave packet propagating without wind at the free surface is compared to the dynamics of the packet propagating in the presence of wind. Wind is introduced in the numerical wave tank by means of a pressure term, corresponding to the modified Jeffreys' sheltering mechanism. The wind blowing over a strongly modulated wave group due to the dispersive focusing of an initial long wave packet increases the time duration and maximal amplitude of the steep wave event. These results are coherent with those obtained within the framework of deep water. However, steep wave events are less unstable to wind perturbation in shallow water than in deep water. Furthermore, a comparison between experimental and numerical wave breaking is presented in the absence of wind. Within the framework of numerical experiments, wind is shown to speed up the wave breaking and amplify slightly the wave height. The wall pressure during the run up of the steep wave event on a vertical wall is investigated too and a comparison between experimental and numerical results is provided.

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MS49

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MS50

Traveling Discrete Modes in the Presence of Small Dissipation

Nonlinear discrete systems appear in many areas of science. In the absence of losses, models like the discrete nonlinear Schroedinger equation, or oscillators under the action of Toda or Morse potentials describe the dynamics of traveling wave solutions (TWS) with many applications. Typically the existence of traveling modes relates to the effect of a Peierls-Nabarro potential. Less is known of the role of dissipation. We will discuss if dissipation slows or even stops TWS.

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MS50

Supersonic Davydov Soliton Propagation in a Discrete Chain

We investigate numerically and asymptotically the supersonic motion of a coherent Davydov type soliton. The model is formulated in terms of the cubic discrete NLS coupled to an anharmonic lattice. The anharmonicity of the lattice allows for the propagation of supersonic compressional waves. This supersonic wave traps the Davydov like soliton producing a coherent supersonic soliton. We find approximate solutions using the continuum approximation and show numerically their stability. It is to be remarked that the sonic regime produces Davydov solitons with finite amplitude which are not present in the usual model. These results were obtained in the parameter regime apro-

priate for simple models for protein chains. This shows the posibility of supersonic propagation of coherent excitation of the peptide groups.

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MS50

Refined Stability of Navier-Stokes Shocks

In the classical (inviscid) stability analysis of shock waves, the stable and unstable regions of parameter space are typically separated by an open set of parameters. Zumbrun and Serre have shown that the precise location of the transition to instability can be determined by an "effective viscosity' coefficient which takes into account viscous effects neglected in the classical theory. In this talk, we discuss the computation of the effective viscosity coefficient for the Navier-Stokes equations.

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MS50

Continuation and Bifurcations of Breathers in the Discrete Nls Equation

We present analytical and numerical results on the continuation and bifurcations of breathers in the discrete NLS equation. The study of bifurcations concerns finite one-dimensional lattice with Dirichlet boundary conditions. We will show evidence for subcritical fold and pitchfork bifurcations as the intersite coupling increases and we will also discuss breathers that can be continued to normal modes of the weakly nonlinear system.

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MS51

Surface Gap Solitons in the Gross Pitaevskii Equation with a Nonlinear Interface

The (1D) Gross Pitaevskii Equation with an inhomogeneity in the form of an interface of two materials with different values of the nonlinear refractive index may support stationary localized solutions called Surface Gap Solitons (SGS). We numerically compute families of SGS by using an arclength continuation method. We show that unlike solitons in linearly homogeneous media, SGS are possible at truly focusing/defocusing interfaces. We then investigate linear stability of SGS via the numerical Evans function method.

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MS51

Fronts and Solitary Waves in Inhomogeneous Wave Equations

After an introduction to the topic of this mini-symposium, this talk will focus on two models involving the inhomogeneous sine-Gordon equation. The first model describes aspects of the DNA/RNAP interaction in DNA copying. The second model involves long Josephson junctions or 0-π junctions with imperfections. The existence of rich families of stationary coherent solutions will be discussed, including stable non-monotonic fronts.

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MS51

Stability in Inhomogeneous Nonlinear Schroedinger Equations

Inhomogeneous nonlinear Schroedinger equations provide models in a variety of settings, recently including both optics and Bose-Einstein condensation. In such models, standing waves can often be constructed via phase-plane techniques. Here, we discuss a method to quickly characterize the stability of many of these standing waves using geometric information available in the phase-plane. As a concrete example, we consider cubic-quintic NLS with an N-well external potential.

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MS51

Effects of Spatial Inhomogeneities on the Stability of Fronts in a Non-linear Wave Equation

The analysis of the non-linear wave equation often assumes a homogeneous potential. However in many applications inhomogeneities may arise. Here we consider a spatial step-like defect and look at the stability of stationary fronts. A condition for points (involving the length of the defect and the energy of the front) where the stability of the front changes is presented as well as a discussion of travelling fronts, including pinning of a travelling front by the introduction of a defect.

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MS52

Existence and Stability of Viscous Shock Profiles

for Isentropic Mhd with Infinite Electrical Resistivity

For the Navier-Stokes equations of isentropic magnetohydrodynamics (MHD) with γ-law gas equation of state, $\gamma \geq 1$, and infinite electrical resistivity, we carry out a global analysis categorizing all possible viscous shock profiles. For the monatomic and diatomic cases $\gamma = 5/3$ and $\gamma = 7/5$, we carry out a systematic numerical Evans function analysis indicating all of the profiles are linearly and nonlinearly stable.

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MS52

The Hamiltonian Structure of the NLS and the Asymptotic Stability of its Ground States

Ground states satisfying conditions for orbital stability by Weinstein are proved asymptotically stable for generic equations with smooth nonlinearity, solving old problem by Soffer and Weinstein from 80's. For Fermi Golden rule we implement Birkhoff normal form argument, as in solution by Bambusi and Cuccagna on stability of trivial solution for NLKG. To save semilinear nature of Hamiltonian, we implement the Darboux Theorem.

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MS52

Spectral Stability of Bose-Einstein Condensates in a Periodic-Trap with Non-Local Effects

In this work, the stability of a class of solutions to a model of a Bose-Einstein condensate in a periodic trap with non-local effects is established numerically. Then, using Bloch decomposition and a Lyupanov-Schmidt reduction, the spectral stability of these solutions is established.

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MS52

The Transverse Instability of Periodic Traveling Waves in the Generalized Kadomtsev-Petviashvili Equation

We consider the spectral instability of periodic traveling wave solutions of the gKdV equation to transverse perturbations in the gKP equation. By analyzing high and low frequency limits of the appropriate periodic Evans function, we derive an orientation index which yields sufficient conditions for such an instability to occur. This index is geometric in nature and applies to arbitrary periodic traveling waves with minor smoothness and convexity assumptions on the nonlinearity. Using the integrable structure of the ordinary differential equation governing the traveling wave profiles, we are then able to calculate the resulting orientation index for the elliptic function solutions of the Korteweg-de Vries and modified Korteweg-de Vries equations.

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MS53

New Singular Solutions of the Biharmonic NLS Equation

We consider blowup-type singular solutions of the fourth-order (biharmonic) nonlinear Schrödinger (BNLS) equation. Our formal and informal analysis, and numerical evidence, indcate that the blowup formation resembles that of the standard (harmonic) NLS. However, the lack of some key analytic tools still makes BNLS theory challenging. In the L^2-critical case, we show that the collapsing core of the solution converges to a self-similar profile, and bound the blowup rate. In the super-critical case we use asymptotic analysis to find and characterize new peak-type and ring-type singular solutions of the BNLS, which also converge to a self-similar profile. These findings are verified numerically, using an adaptive mesh, at focusing factors of up to 10^8. Joint work with Gadi Fibich and Elad Mandelbaum.

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MS53

Nonlinear Imaging through Random Media

Scattering of signals through random media is a pervasive problem in imaging. Linearly, ray diffusion leads to loss of contrast and effective noise. Nonlinearly, wave coupling between signal and noise leads to energy exchange between the components. For the right parameters, signal can grow at the expense of noise. Here, we describe this dynamical "stochastic resonance" using the formalism of photonic plasma. Experimentally, we demonstrate the technique by recovering diffused images using a photorefractive crystal.

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MS53

Dynamics and Transport of Localized Wave Packets in Random Nonlinear Systems

We study the long time behavior of solutions to the nonlinear Schrödinger equation with random initial conditions. It is shown that the dynamics of a random initially localized wavepacket is either diffusive, localized or super diffusive.

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MS54

Modeling Multi-Pulsing Transition in Ring Cavity Lasers with Proper Orthogonal Decomposition

A low-dimensional model is constructed via the proper orthogonal decomposition (POD) to characterize the multi-pulsing phenomenon in a ring cavity laser mode-locked by a saturable absorber. Constructing a bifurcation diagram for the reduced four-mode model explains the transition from a single mode-locked pulse to a double-pulse configuration. It is shown that the single mode-locked pulse undergoes a Hopf bifurcation, and the created periodic solution undergoes a fold bifurcation after which only the double-pulse solution remains stable. The low-dimensional model also shows the coexistence of solutions with different number of pulses. These findings are in good agreement with the full governing equation.

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MS54

The Short Pulse Master Mode-locking Equation

We propose a new model which is valid for pulse propagation in a mode-locked laser cavity in the few-femtosecond regime. This alternative to the master mode-locking equation is valid beyond the breakdown of the slow envelope approximation. Perturbing the Short Pulse Equation with dissipative gain and loss terms allows the generation of stable ultra-short pulses from initial white-noise. This provides an initial theoretical framework for quantifying dynamics and stability as pulses approach the attosecond regime.

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MS54

Mode-Locking Using Phase-Sensitive Amplification

A method is proposed and considered theoretically for using phase-sensitive amplification as the intensity-discrimination (saturable absorption) element in a laser cavity to generate stable and robust mode-locking. The resulting averaged equation is a Swift-Hohenberg type model with cubic-quintic nonlinearities and a linear growth term which couples to the nonlocal cavity energy.

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MS54

Dynamics and Timing Jitter of a Ytterbium Fiber Laser

We study the dynamics of the high power femto-second pulses generated in lasers with normal average dispersion that incorporate a normal Ytterbium fiber amplifier and anomalous dispersion compensation. Stable operation is permitted provided the total dispersion is normal and does not fall below a power-dependent threshold. Whereas the chirp of a stable pulse is always positive, unstable operation occurs when the chirp undergoes large swings about zero. We discuss implications for minimization of timing jitter.

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MS55

Adaptive Space-time Discontinuous Galerkin Schemes for the Simulation of Gravitational Collapse

We present a class of adaptive, high-order, discontinuous Galerkin schemes for solving the spherically symmetric Einstein equations. The time-stepping strategy is to allow different time-steps in each element (i.e., large time-steps on coarse mesh elements and small time-steps on fine mesh elements). High-order in space is achieved through the discontinuous Galerkin approach, while high-order in time is achieved via a Lax-Wendroff-type of space-time expansion. Different error indicators for the adaptive mesh refinement part of the algorithm will be considered. The proposed approach will be validated on a few different problems involving the gravitational collapse of a scalar field.

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MS55

Numerical Simulation of a General Relativisitic Shock Wave by a Locally Inertial Godunov Method

with Dynamic Time Dilation

We discuss the doctoral dissertation of Zeke Vogler in which he demonstrates numerical convergence of a locally inertial Godunov method, which incorporates a new dynamic time dilation to account for general relativistic e ffects of curvature. He gives a complete proof that pointwise a.e. convergence together with bounded total variation implies convergence to a weak solution, and then demonstrates the two assumptions numerically. The convergence is for a new set of initial data that meets the constraints of the Einstein equations when $p \neq 0$, and solutions are interesting in their own right. For example, one can view the forward time evolution as resolving the secondary wave in exact models for an explosion into a static singular isothermal spherefirst constructed by Smoller and Temple. In backward time, the numerics demonstrate formation of a black hole in the evolution of a smooth solution. The components of the gravitational metric are only Lipshitz continuous at shock waves, so the curvature could in principle have delta function sources at shocks, but the convergence to a weak solution rules this out. The point of departure for the work is the locally intertial Glimm scheme first introduced and analyzed by Groah and Temple.

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MS55

Gravitational Waves from Extreme-mass-ratio Binary Black Hole Inspirals

The inspiral of stellar-mass ($m \sim 10M_\odot$) compact objects into supermassive black holes ($M \sim 10^6 M_\odot$) should be a strong source of gravitational waves (GWs) for the planned LISA space-based gravitational-wave observatory. As a step towards calculating the expected GW signal from such a source, here I consider the problem of calculating the $\mathcal{O}(\Updownarrow/\mathcal{M})$ "self-force' on the small body due to gravitational radiation reaction, using characteristic AMR in the Barack-Ori mode-sum regularization procedure.

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MS55

Recent Advances in Modeling Gravitational Recoil from Highly-spinning Black-hole Binaries

The recent advances in the fully nonlinear modeling of merging black-hole binaries led to remarkable breakthroughs in our understanding of black-hole dynamics. One of the most unexpected and exciting discoveries was that when highly-spinning binaries merge the resulting black hole can recoil at up to 4000 km/s, fast enough to eject the remnant from even the largest galaxies. These remarkable results were obtained by sampling only a small fraction of the seven dimensional parameter space of possible binaries. The challenge now is to extend these simulations to the high-spin and extreme-mass-ratio regimes in order to develop models that can accurately predict the recoil of binaries from the full parameters space with sufficient accuracy for astrophysical applications.

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MS56

From the Pearcey Process to the Airy Process: A Fredholm Determinant Approach

In this joint work with Mattia Cafasso we show how to set up a Riemann–Hilbert formulation relevant to the Fredholm determinant of the Pearcey kernels. This Riemann–Hilbert problem is conducive to asymptotic analysis and we show how the Fredholm determinant of the Pearcey kernel asymptotically reduces (for large values of the gaps) to the product of two Fredholm determinants of the Airy kernel.

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MS56

On the Modulation Equations and Stability of Periodic GKdV Waves

In this talk, we will discuss recent results concerning the rigorous justification of the Whitham modulation equations for periodic traveling wave solutions of the gKdV equations. We will begin by outlining how to derive the Whitham equations in the case where the underlying periodic wave has non-zero average. We will then discuss how to prove these homogenized equations describing the mean behavior of a slow modulation (WKB) approximation of the solution correctly describes the linearized dispersion relation near the origin. In particular, we will describe two techniques for showing that the modulational stability of the underlying periodic wave is equivalent with the well-posedness of the Whitham system: the first via direct Evans function calculations and the second using more general Bloch-wave decompositions. The latter method has the distinct advantage of applying in the more general multi-periodic setting where no conveniently computable Evans function is yet devised.

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MS56

Dispersionless Limits of Integrable Systems and Universality in Random Matrix Theory

The τ-functions of the Toda and Pfaff lattice hierarchies are given by the partition functions of the Gaussian unitary, orthogonal and symplectic ensembles of random matrices. In these cases the asymptotic expansions of the free energies given by the logarithm of the partition functions lead to the dispersionless limits of the Toda and Pfaff lattice hierarchies. There is a universality between all three ensembles of random matrices, one consequence of which is that the leading orders of the free energy for large matrices agree. We show that the free energy as the solution of the dispersionless Toda lattice hierarchy gives a solution of the dispersionless Pfaff lattice hierarchy, which implies that this universality holds in general for the leading orders of the unitary, orthogonal and symplectic ensembles.

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MS57

Log Concavity of Solutions to the Diffusive Lifschitz-Slyozov-Wagner Equation and Coarsening

The classical Lifschitz-Slyozov-Wagner (LSW) model is one of the simplest models of coarsening. Recently the speaker proved point-wise in time bounds on the rate of coarsening for the LSW model by using convexity methods. In this talk we shall discuss how these methods may be extended to diffusive LSW by showing that the set of log concave functions is invariant under a diffusive LSW flow with the simplest diffusion term.

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MS57

Scaling Limits for Deformations of Hermetian Random Matrix Ensembles and their Self-Similar Solutions

We will describe various scaling limits of the free energy for Hermetian random matrix ensembles. We derive very detailed information about the asymptotic behavior of correlation functions for the underlying Gibbs measures by studying the corresponding scaling limit of the Toda lattice dynamical system associated to parameter variations of the ensemble partition functions. The continuum limit is a forced Burgers hierarchy having self-similar solutions that we are able to explicitly compute. Our goal will be to sketch what goes into deriving this hierarchy and constructing the self-similar solutions. Time permitting, we will also describe new implications for a related double-scaling limit that arose twenty years ago in the context of 2D quantum gravity. Applications of these results will also be discussed in a related talk in session MS47.

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MS57

Diagonalizing Random Matrices Using Integrable Systems

The QR algorithm is known to be the time one map of an integrable Hamiltonian system on certain classes of matrices. I will explain this fact and introduce the related Toda algorithm. As a first step towards the probabilistic analysis of these algorithms we are trying to understand the time it takes to identify one of the eigenvalues up to a prespecified tolerance given an initial matrix drawn from the 1-Hermite ensemble. Numerical simulations will be presented that lead to conjectures regarding the existence of scaling limits for this and related random times in case of both the QR and the Toda algorithm.

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MS57

The Spectral Edge of Beta Ensembles

Consider n particles on the line, each subject to the same (convex) polynomial potential and jointly to a coulombic interaction of strength $\beta > 0$. We prove that the renormalized law of the largest point converges to the "Beta Tracy-Widom" distribution, generalizing well known earlier results from Random Matrix Theory pertaining to $\beta = 1, 2, 4$ and analytic potentials, or to quadratic potential and the full range of β. This is joint work with Balint Virag and Manjunath Krishnapur.

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MS58

Shear Stability of Stratified Flows with a Free Surface

Abstract not available at time of publication.

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MS58

Internal Solitary Waves: Finite-amplitude Equilibria and Nonlinear Evolution

A new method for computing steady finite-amplitude internal waves in a general stably-stratified fluid is presented. These solutions include trapped, nearly-stagnant cores of uniform density for large amplitude. Novel nonlinear simulations at infinite Prandtl number confirm the stability of many of these solutions. Others exhibit partial breakdown via Kelvin-Helmholtz instability.

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MS58

Spectral Evolution and Instabilities of Nonlinear Deep-Water Ocean Waves

In this work we concentrate on the development of an accurate and efficient numerical model for a short-term prediction of evolving nonlinear ocean waves, including extreme waves such as Rogue waves. Derivations of asymptotically reduced models, based on the small wave steepness assumption, as well as relatively weak transverse dependence, will be presented and their corresponding numerical simulations via Fourier pseudo-spectral methods will be discussed. Motivated by their spectral evolution, the stability of a weakly nonlinear wave-train (Stokes wave) on deep water subject to three-dimensional modulations is investigated.

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MS58

Title Not Available at Time of Publication

Abstract not available at time of publication.

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MS59

Power-dependent Soliton Dynamics in Complex-photonic Structures

Abstract not available at time of publication.

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MS59

Parity-time Symmetric Optical Lattices

Interestingly, non-Hermitian Hamiltonians that respect paritytime (PT) symmetry can show entirely real spectra. It has been recently realized that PT-related notions can be experimentally investigated in the context of optics. We report the first experimental observation of a PT optical coupled system. We also study the peculiar properties of PT-optical lattices such as abrupt phase transitions, power oscillations, band merging, non-orthogonal Floquet-Bloch modes, nonreciprocal diffraction patterns, double refraction, phase dislocations, and solitons.

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MS59

The Discrete Short Pulse Equation and its Solutions

The short pulse (SP) equation was derived recently as a model equation for the propagation of ultra-short optical pulses in nonlinear media. The SP equation admits various interesting exact solutions such as loop soliton solutions and breather solutions. In this talk, we propose new integrable semi-discretization and fully discretization of the SP equation by using the method proposed by us recently. We also discuss properties of various exact solutions of the discrete SP equation.

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MS59

On the Stability of Sonic Viscous Shock Waves

In this talk I shall make simple observations leading to optimal decay rates in L^p spaces for zero-mass perturbations of degenerate (or sonic) viscous shock waves. The method uses energy estimates and weighted interpolation inequalities, based on the Matsumura-Nishihara weight function. The approach is elementary and applies to shocks of all order of degeneracy.

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MS60

An Experimental Investigation of Localization in Nonlinear Granular Elastic Crystals

We experimentally investigate localization in one-dimensional nonlinear granular crystals composed of statically compressed spheres that interact via Hertzian contact. We show linear spectrums in monatomic and diatomic crystals. Intrinsic localization is shown in diatomic crystals resulting from a modulational instability of the lower optical band edge. We identify nonlinear localization arising from defects in monatomic crystals, and study the effects of the dynamic excitation amplitude and defect spatial proximity on the frequency of these modes.

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MS60

Fermi, Pasta, Ulam, and the Birth of Experimental Mathematics

In May 1955, Los Alamos Report LA-1940 ("Studies of Nonlinear Problems. I") was published by Enrico Fermi, John Pasta, and Stanislaw Ulam (FPU). Containing what is now universally known as the "FPU problem", the study initiated a revolution in modern science, ushering in the age of computational science and marking the birth of nonlinear science as an interdisciplinary field. On one hand, computational and analytical studies attempting to explain the surprising FPU recurrences led to the discovery of solitons. On the other, similar explorations of "simple" (low-dimensional) systems related to the FPU problem have led to the widespread modern awareness of deterministic chaos. Today, analyses of the FPU problem continue to lead to deeper insights into many areas–including the interplay between regular and chaotic behavior, the behavior of spatially extended but discrete nonlinear systems, heat conduction anomalies in low-dimensional systems, and the origins of statistical mechanics. In this talk, I'll discuss some of this history and indicate some exciting results that are helping to continue the story's development.

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MS60

Nonlinear Resonance Processes in Driven Granular Alignments

We consider axially aligned elastic spheres confined within walls. Both monosized and tapered chains are considered. These grains repel via Hertz law. When driven at one end, the system begins to undergo continuous sequences of overcompression and dilation. The frequency of this breathing can be tuned by varying the geometric and mechanical properties of the elastic objects. We shall discuss how this system naturally allows one to detect very low frequencies and suggests a way of extracting energy from sources such as ocean waves, wind energy etc.

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MS60

Energy Localization in Nonlinear Granular Elastic Crystals

We study localization of energy in one-dimensional chains of tightly packed and uniaxially compressed elastic beads. For monoatomic chains, the inclusion of light-mass impurities is crucial for the appearance of energy localization. For diatomic chains, the localization is obtained by the intrinsic nonlinearity, caused by the Hertzian interaction of the beads, without additional inhomogeneities. We first characterize the linear spectrum of the system. We then use continuation techniques to find the exact nonlinear localized solutions and study their linear stability in detail.

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MS61

Integration of Stationary Equations for KdV Multisolitons

Just as the solitary-wave profiles for the KdV equation can be obtained by integrating a second-order ordinary differential equation, N-soliton profiles can be obtained by integrating an ordinary differential equation of order 2N, which is actually a Hamiltonian system with N degrees of freedeom. Gelfand, Dickey, and Dubrovin showed how to explicitly integrate the system to find its periodic solutions. We use the same method to classify all the homoclinic orbits of the system, in the case N=2. Since the homoclinic orbits are 2-solitons, this result leads to an improvement of the stability theory of Maddocks and Sachs for 2-solitons.

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MS61

Hopf Instabilities of Defect Modes

Localized solutions of nonlinear wave equations in the presence of inhomogeneities–defect modes–are generally stable at small amplitudes and unstable at larger amplitudes. A lot of attention has been paid to symmetry-breaking bifurcations. We construct inhomogeneities that force Hamiltonian Hopf bifurcations, and analyze the bifurcating solutions.

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MS61

Spectral Analysis for Matrix Hamiltonian Operators

In this result, we study the spectral properties of matrix Hamiltonians generated by linearizing about soliton solutions to nonlinear Schrödinger equations. Using a hybrid analytic-numerical proof, we show that there are no embedded eigenvalues for the three dimensional cubic nonlinearity and other nonlinearities. Though we will focus on a complete proof for the $3d$ cubic problem, the true nature of the work is to present a new, robust algorithm for verification of the spectral properties required for stability analysis of linearized Schrödinger operators. However, there are several cases of interest for which our current methods are inconclusive, the reasons for which we explore in as much detail as possible.

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MS61

Stability of Higher Order Curvature Driven Flows

We discuss the linear and nonlinear stability of a class of higher order curvature drive flows which arise in the models of solvated functionalized polymers. We outline the derivation of the sharp-interface reduction, and show that so long as the fronts are non-self intersecting, the curvature driven flow gives the correct leading order normal velocity.

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MS62
Spatiotemporal Complexity of the Parametrically Driven Damped Nonlinear Schrödinger Solitons

This talk focusses on time-periodic solitons of the parametrically driven damped nonlinear Schrödinger equation. Unlike the traditional approach based on direct numerical simulations, we determine the periodic solitons as solutions of the boundary-value problem on a two-dimensional domain. This allows us to obtain both stable and unstable solutions and study their bifurcations. We demonstrate the increasing complexity of localised attractors as the amplitudes of the damping and driving are raised: simple periodic solutions give way to multiple-periodic ones; free-standing solitons are replaced by their stable complexes.

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MS62
Localized States in Parametrically Driven Quasi-reversible Systems

We study theoretically a family of localized states which asymptotically connect a uniform oscillatory state in the magnetization of an easy-plane ferromagnetic spin chain when an oscillatory magnetic field is applied and in a parametrically driven damped pendula chain. The conventional approach to these systems, the parametrically driven damped nonlinear Schrdinger equation, does not account for these states. Adding higher order terms to this model we were able to describe these localized structures.

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MS62
Symmetry and Mobility of Discrete Solitons in a Forced-damped Array of Coupled Pendula

We present an experimental system - a driven array of coupled pendula - in which a stability reversal between forced discrete solitons of different symmetry is observed. We compare experimental results to detailed numerical phase diagrams for stable on-site and inter-site centered localized modes. For lattice parameters close to the transition between the two 'phases', the Peierls-Nabarro barrier vanishes and enhanced mobility of the localized mode is observed.

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MS62
A New Stability Criterion for Nonlinear Schroedinger Solitons with Spatiotemporal Driving

We develop a collective coordinate theory for solitons of the Nonlinear Schroedinger Equation (NLSE) with spatiotemporal forces of the form f(x,t) = a exp[i K(t) x]. We consider constant, harmonic and biharmonic K(t). We conjecture a new stability criterion: if the curve P(V), where P(t) and V(t) are the soliton momentum and velocity, has a branch with negative slope, the soliton is predicted to become unstable which is confirmed by our simulations for the perturbed NLSE. This curve also yields a good estimate for the soliton lifetime: the shorter the branch with negative slope is, the longer the soliton lives.

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MS63
A Perturbation Theory for Dispersion-managed Solitons in Femtosecond Lasers

I will review a recently developed perturbation theory for dispersion-managed solitons. The theory, which generalizes the familiar tools available for the nonlinear Schroedinger equation, does not require the underlying dynamics to be integrable, and it can be applied to quantify the effects of noise in dispersion-managed systems.

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MS63
Discussion: Future Directions and Open Problems on Mode-locked Lasers

We provide a forum for moderated discussion among minisymposium participants to address open problems in the modeling, analysis, and simulation of high-power short-pulse mode-locked lasers.

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MS63
Modelling of Figure-eight All-fiber Laser

The figure-eight fiber laser is considered in two configurations, with either a unidirectional active ring cavity coupled with a nonlinear optical loop mirror (NOLM) or a unidirectional passive cavity and a nonlinear amplifying loop mirror (NALM). In each case, we derive a master equation of cubic complex Ginzburg Landau (CGL) type, in which the coefficients explicitly depend on the characteristics of the cavity. Single-pulse and continuous wave (cw) solutions in both normal and anomalous dispersion are discussed analytically.

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MS63
Analysis of Dark and Bright Solitons in Mode-Locked Lasers

The formation and behavior of both dark and bright pulses in mode-locked lasers is studied using adiabatic perturbation theory. In the anomalous regime individual pulses are well approximated by soliton solutions of nonlinear Schrodinger equation with key parameters evolving slowly in time. In the normal regime both dark and bright soliton pulse are found. The dark pulses are well approximated by solutions to the NLS equation with a shelf propagating away from the soliton.

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Title Not Available at Time of Publication

Abstract not available at time of publication.

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MS64
Linear Stability, Price Law and Wave Decay on Black Hole Metrics

Price's Law states that linear perturbations of a Schwarzschild black hole, depending on initial conditions, fall off as t^{-2l-3} or t^{-2l-2} for t approaching infinity, where l is the angular momentum. We give a rigorous proof of these decay rates in the form of weighted L1 to L^{infty} bounds for solutions of the Regge Wheeler equation. The proof is based on an integral representation of the solution which follows from spectral theory. We apply two different perturbative arguments in order to construct the corresponding spectral measure and the decay bounds are obtained by appropriate oscillatory integral estimate.

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MS65
Coherent Structures and Phase Transitions in Stochastic Neuronal Network Dynamics

We consider a network of pulse-coupled oscillators containing randomness both in input and in network architecture. We analyze the scalings which arise in certain limits, demonstrate limit theorems in the correct scaling, and interpret various "finite-size" effects as perturbations of these limits. We also observe that for certain parameters, this network supports both synchronous and asynchronous modes of behavior and will switch stochastically between these modes due to rare events. We also relate the analysis of this network to results in random graph theory, and in particular, those involving the size of the "giant component" in the Erdős-Rényi random graph and use this to understand the phase transitions in the system.

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MS65
Integrable Stochastic Soliton Dynamics of Light Polarization in an Active Medium

Resonant interaction of light with a randomly prepared, active optical medium in the lambda configuration is described by exact solutions of a completely-integrable, random partial differential equation, thus combining the opposing concepts of integrability and disorder. An optical pulse passing through such a material will switch randomly between left- and right-hand circular polarizations. Exact probability distributions of the electric-field envelope variables describing the light polarization will be presented and their properties discussed.

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MS65

Parameterization of Turbulent Transport by Mesoscale Eddies

We employ homogenization theory to develop a systematic parameterization strategy for quantifying the transport effects of mesoscale coherent structures in the ocean which cannot be well resolved by large-scale weather and climate simulations. We work from the ground up with simple kinematic models and study in particular how the effective diffusivity depends on the governing parameters, such as Strouhal number and Peclet number, in a class of random time-dependent vortex flows.

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MS65

Properties of Kinetic Models of Shock Clustering

This talk is a description of some mathematical properties of kinetic models of shock clustering.

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MS66

A Model for Energy Dissipation due to Wave Breaking

Abstract not available at time of publication.

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MS66

Title Not Available at Time of Publication

Abstract not available at time of publication.

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MS66

Higher Order Bragg Resonance of Water Waves by Large Amplitude Bottom Corrugations

Strong and constructive scattering occurs when water waves propagate over bottom corrugations whose wavelength is close to an integer multiple of half a water wavelength. Exact solutions of these higher order Bragg resonances are developed for finite amplitude corrugations using a Floquet theory of linearized water waves. We examine the ranges of water wave frequencies, within which the wave amplitude exhibits slow exponential modulation in space, and outside which slow sinusoidal modulation occurs. The effects of these higher order Bragg resonances are illustrated using the normal modes of a rectangular tank. In collaboration with Louis N. Howard, Department of Mathematics, MIT. Support of J. Yu by National Science Foundation (Grants CBET-0756271, CBET-0845957) is gratefully acknowledged.

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MS67

Orthogonal Degree and Bifurcation in the Periodic Nonlinear Schrdinger Lattice

We analyze a circular discrete NLS equation, this is, a lattice of n oscillators with periodic conditions. This lattice has an explicit rotating weave, wich is a relative equilibrium, where all oscillators have the same amplitude and differing faces. Using the amplitude of the rotating weave as parameter, we prove bifurcation of symmetric relative equilibria from the rotating wave. In addition, we use orthogonal degree to prove bifurcation of symmetric periodic solutions. The symmetries of the periodic solutions let us conclude that these solutions are traveling waves, where the faces oscillate with two different periods.

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MS67

Interlaced Linear-nonlinear Optical Waveguide Arrays

Continuous as well as periodic wave solutions in a system of coupled discrete equations describing a two component superlattice with interlaced linear and nonlinear constituents and the associated modulational instability are fully analytically investigated and numerically tested for focusing and defocusing nonlinearity. This system is the basis for investigating binary waveguide arrays. This system exhibits an extra band-gap controlled by a relative detuning. A variety of stable discrete solitary modes, are found and discussed.

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MS67

Exactly Energy-Momentum Conserving Discretizations for Large, Stiff Hamiltonian Systems, Applied to Davydov-Scott Models of Energetic Pulses in α-Helix Protein

Long-range energetic pulse propagation in α-helix protein has been modeled by Davydov, Scott and others with Hamiltonian ODE systems, which in a continuum limit and a singular "infinite stiffness' limit, lead to the integrable NLS Equation. The soliton solutions of the latter suggest the possibility of coherent long-range propagation of energetic pulses in such proteins. These predictions need to be tested with more accurate models, as each limit can fundamentally change the nature of solutions. As exact solutions are unknown, numerical solution of these large, stiff Hamiltonian systems is needed. Simulation is done by introducing a time discretization method based on discretizing the Hamiltonian form using a finite difference calculus for gradients. This ensures exact conservation of all conserved quantities and allows a simple, highly stable iterative method for solving the resulting implicit system.

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MS67

Asymptotic Stability of Radiative Shocks in Multidimension Spaces

Abstract not available at time of publication.

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MS68

Splitting Induced Generation of Soliton Trains in Layered Elastic Structures

I will discuss our recent analytical and experimental studies of long nonlinear bulk waves in layered elastic waveguides, including wave scattering by inhomogeneities modelling poor adhesion or delamination. The emphasis is on classical and radiating solitary waves. In particular, we study the dynamics of a long longitudinal bulk strain solitary wave in a split, symmetric layered bar, made of a hyperelastic (Murnaghan) material. The developed approach is based on matching two asymptotic multiple-scale expansions, integrability theory of the leading order KdV equations by the Inverse Scattering Transform and some natural radiation conditions. We show that splitting of the layered structure induces a generation of a train of secondary solitary waves from a single incident soliton, and thus, can be used to detect the defect. The theory is supported by experiments, performed in the Ioffe Institute in St. Petersburg (Russia), using holographic interferometry and laser induced generation of a compression solitary wave in two- and three-layered polymethylmethacrylate (PMMA) bars, bonded using ethyl cyanoacrylate-based (CA) adhesive. Possible applications of the described phenomenon include introscopy of layered structures and seismology.

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MS68

Pulse Propagation in Granular Chains

Granular media can support excitations ranging from the very localized to the very dispersive. Experimental and numerical studies of pulse propagation in granular chains have helped to understand energy propagation in these nonlinear discrete one-dimensional media. However, the predictive capability of most existing work has been limited by the dearth of analytic results. We introduce a binary collision approximation that yields quantitatively accurate analytic results for chains of different granular geometries, mass, and/or size distributions.

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MS68

Periodic and Shock Waves in Strongly Nonlinear Two-Mass Chains

Periodic and shock waves were investigated in nonlinear and strongly nonlinear two-mass granular chains composed of steel cylinders and steel spheres. The presentation will outline the first experimental data related to the propagation of these waves in nonlinear and strongly nonlinear chains. The dynamic compressive forces were detected using gauges imbedded inside particles at depths equal to 4 cells and 8 cells from the entrance gauge detecting the input signal. At these relatively short distances we were able to detect practically perfect transparency at low frequencies and cut off effects at higher frequencies for nonlinear and strongly nonlinear signals. We also observed transformation of oscillatory shocks into monotonous shocks. Systems which are able to transform nonlinear and strongly nonlinear waves at small sizes of the system are important for practical applications such as attenuation of high amplitude pulses. We also perform numerical calculations of signal transformation by non-dissipative granular chains which demonstrated transparency of the system at low fre-

quencies and cut off phenomenon at high frequencies in reasonable agreement with experiments.

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MS68

Solitary Waves and Stability in Lattices and Fluids

I will recount progress regarding the robustness of solitary waves in nonintegrable model systems such as FPU lattices, and discuss progress toward a proof (with Shu-Ming Sun) of spectral stability of small solitary waves for the 2D Euler equations for water of finite depth without surface tension.

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MS69

Nonlinear Stability of Semi-discrete Shocks for Two Sided Schemes

We prove that spectrally stable Lax shocks in semidiscrete conservation laws involving spatial forward-backward discretization schemes are nonlinearly stable. The proof involves a construction of the resolvent kernel using exponential dichotomies, recently developed in this setting, and uses the associated contour integral for the Green's function to derive pointwise bounds. Previous results for semidiscrete shocks relied on Evans functions, which exist only for one-sided schemes.

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MS69

Traveling Waves in Exothermic-endothermic Chemical Reactions

We consider solutions of front type in a class of reaction-diffusion systems which represent exothermic-endothermic chemical reactions. There is a linear algebraic relation satisfied along any travelling wave solution, coming from an invariant of the equations in the system. On the spectral level the front solution is known to be marginally unstable. Our recent analytic results show that on the nonlinear level the instability of the front is of a convective nature.

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MS69

Stability of Planar Layers in Systems with Conserved Quantities

We prove the stability of layers in systems exhibiting a conservation law coupled with a reaction diffusion equation. The key element of the analysis is to find a homotopy to a lower-triangular PDE system that has stable solutions and to control the essential spectrum during the homotopy. The layers can destabilize during the homotopy only in the case when a Hopf bifurcation occurs. We use a Lyapunov-Schmidt analysis in weighted spaces to show that eigenvalues can not pop out of or disappear into the essential spectrum during the homotopy.

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MS69

Network Formation in Polymer Electrolytes

The formation of conductive networks within mixtures of functionalized polymers and solvents is essential to many types of energy conversion devices, such as polymer electrolyte membrane fuel cells, bulk-heterojunction solar cells, Gratzel solar cells, and lithium ion batteries, to name a few. We outline a novel energy structure which gives excellent qualitative agreement with experiment, and show that the associated conservative gradient descent flows generate pore-like networks whose meander patterns are readily predicted by the associated sharp interface reduction.

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PP0

Lie point symmetries and Wave Equations on Manifolds

In this presentation we discuss Lie point symmetries of a nonlinear wave equation that arises as a consequence of a Lorentzian metric of signature -2. Apart from showing how geometry can be responsible in giving rise to a nonlinear wave equation, we present a systematic way of using the Lie point symmetries to find its exact solutions. Some interesting physical conclusions relating to conservation laws are also discussed.

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PP0

Effects of Dispersive Radiation on the Phase of Stochastically Perturbed Optical Solitons in Simulations

We demonstrate that soliton perturbation theory, though widely used, does not account for dispersive radiation and therefore predicts an incorrect phase distribution for optical solitons of the stochastically driven nonlinear Schrodinger equation (NLSE). We propose a simple variational model that accounts for the effect of dispersive radiation on the phase evolution and correctly predicts its distribution. We then extend this model to stochastically driven NLSE with dispersion management.

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PP0

Vaccinating Against Hpv in Dynamical Social Network

We develop a dynamical network model to examine the relative merits of strategies for vaccinating women against the sexually transmitted Human Papillomavirus, which can induce cervical cancer. The model community is represented as a sexual network of individuals with links dynamically created and destroyed through statistical rules based on the node characteristics. Various strategies for distributing an allotted number of doses of vaccine are tested for effectiveness in reducing the incidence of cervical cancer.

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Power-Dependent Soliton Dynamics in Complex Photonic Structures

In simple photonic structures with monochromatic modulation of the linear refractive index, soliton dynamics do not depend on their power and width. In this work, we show that for more complex photonic structures where the linear and/or nonlinear refractive indices are modulated by more than one wavenumbers, soliton dynamics depends on their characteristics. It is also shown that, at the interface between two periodic structures, soliton reflection, transmission, and trapping depends strongly on its characteristics.

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PP0

Design of the Potential in Schroedinger-Type Equations to Minimize Radiative Loss

We consider a quantum particle in the ground state of Schroedingers Equation with a localized potential. If the particle is parametrically forced, the eigenfunction becomes a resonant state and decays to zero according to Fermis Golden Rule. We pose the Design Problem: what potential maximizes the lifetime of this resonant state? This is formulated and studied as a constrained optimization problem. Optimal potentials emerge which are periodic with a localized defect. We discuss extensions to the nonlinear Schroedinger equation.

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PP0

Approximation of Detailed Hodgkin-Huxley-Type Neuronal Models by Exponential Integrate-and-Fire Models

Using current-voltage curves and spike metrics, develop optimal strategies are developed for finding the parameters in the exponential integrate-and-fire point neuron model with adaptation current that give the best approximation to the membrane potential and firing rate dynamics of a corresponding Hodgkin-Huxley-type model. The adaptation current is modeled explicitly, but has a prescribed jump at each spike time. The results of computations using both systems give excellent agreement. Bifurcations in both models are compared.

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PP0

Effects of Non-Linearity and Disorder on Localization of Light in Optical Fiber Arrays

Light propagating through optical fiber arrays tends to localize in only a few center cores. Recent experiments in two-dimensional single-mode optical fiber arrays suggest that an interplay of deterministic and random linear and nonlinear effects might be responsible for this localization. We study this phenomenon, both analytically and numerically, in a hexagonal optical fiber array similar to that used in the experiments. Our analysis reveals that Anderson localization is evident in the linear and intermediate regimes, where a larger fraction of initial energy is returned to the center fiber due to the stochastic effects. For very high levels of input energy, the system is strongly nonlinear, with the randomness amplifying the Kerr localization. Additionally, we explore the role of disorder and nonlinearity on the coherent coupling in fiber laser arrays.

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PP0

The Isentropic Euler System Admits Some Plane Wave Superpositions

A class of differentiable solutions is proved for the isentropic Euler equations in three space dimensions. The solutions are explicitly given in terms of three solutions to the inviscid Burgers equation, and three directions of propagation. The relative orientation of the directions is critical. Within the directional constraints, the Burgers solutions are arbitrary. These solutions cannot exist beyond the time when shocks develop in any of the Burgers solutions.

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PP0

Autoresonant Four-Wave Mixing in Optical Fibers

A theory of autoresonant four-wave mixing (FWM) in tapered fibers is presented in application to optical parametric amplification (OPA). In autoresonance the interacting waves stay phase-locked continuously despite the tapering. This spatially extended phase-locking allows complete pump depletion and flat, wide frequency band amplification. Different aspects of autoresonant OPA are described including initial phase-locking, conditions for autoresonance, stability, and spatial range of autoresonant interaction. The theory is applicable to other autoresonant FWM processes.

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