IP0
Martin D. Kruskal Lecture - Pattern Quarks and Leptons

Martin Kruskal was one of a kind, a pure scientist who followed roads less travelled by and whose new discoveries made all the difference in so many ways. Once a question intrigued and gripped him, he never let go. The discovery of solitons and the uncovering of whole new classes of integrable systems have led to major advances in the worlds of Hamiltonian partial differential equations, in exactly integrable models in statistical physics, and to the fascinating and more recently discovered properties of random matrices. And there may be yet many more windfalls to come. In this Kruskal lecture, I will give a brief overview of some of the early days, of how Martin took on the Fermi, Pasta, Ulam conundrum which had defied explanation by some of the best minds of the time and, with the help of colleagues Zabusky, Miura, Gardner and Greene, turned it into one of the most important discoveries of the last half of the 20th century. As for my own contributions to today's lecture, I have no illusions that the story I shall tell will have any of the same impact but hope that it will reflect some of the same pioneering spirit that Martin displayed in pursuing the unconventional. What I plan to do is sketch some ideas I have been mulling in connection with the Standard Model and show that quark and lepton like objects with different masses and all the invariants associated with spin (+/-1/2) and charge (+/-1/3,+/-2/3,+/-1) can occur naturally as the result of phase transitions in far from equilibrium, pattern forming systems. In contrast to the Standard Model, they arise without any a priori introduction of the SU(2) and SU(3) symmetries into the governing free energy. The invariants can each be connected to the condensation of mean and Gaussian curvature of the constant phase surfaces along certain defect cores.

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IP1
Stability and Synchrony in the Kuramoto Model

The phenomenon of the synchronization of weakly coupled oscillators is a old one, first been described by Huygens in his "Horoloquium Oscilatorium.' Some other examples from science and engineering include the cardiac pacemaker, the instability in the Millenium Bridge, and the synchronous flashing of fireflies. A canonical model is the Kuramoto model

$$\frac{d\theta_i}{dt} = \omega_i + \gamma \sum_j \sin(\theta_j - \theta_i)$$

We describe the fully synchronized states of this model together with the dimensions of their unstable manifolds. Along the way we will encounter a high dimensional polytope, a Coxeter group, and a curious combinatorial identity. This leads to a proof of the existence of a phase transition in the case where the frequencies are chosen from an iid Gaussian distribution.

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IP2
Kramers' Law - Validity and Generalizations

Consider the overdamped motion of a Brownian particle in a multiwell potential. Kramers' Law describes the small-noise limit of the particle's mean transition time between local minima. We will outline several approaches to the problem of describing such noise-induced transitions, discuss recent generalizations of Kramers' Law to potentials with nonquadratic saddles and stochastic partial differential equations as well as the limitations of the law such as the cycling effect. Generalizations and refined results on cycling are joint work with Nils Berglund (Orleans).

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IP3
Fluid Ratchets and Biolocomotion

In this talk, I will discuss a few laboratory experiments where moving structures freely interact with the surrounding fluid. These moving structures, or boundaries, behave in asymmetric ways - either because of their anisotropic construction or by the spontaneous breaking of symmetry in their response to the fluid. When subjected to reciprocal forcing, their motion might be described as a ratcheting behavior. In one case, a fluid is forced through a corrugated channel that is under shaking. In another, a solid body hovers stably in an oscillatory airflow, mimicking a hovering insect. Lastly, a symmetric wing leaps into a forward flight when flapped up and down, following a symmetry breaking bifurcation. These phenomena can be viewed as the starting points for understanding the effect of increasing biological realism.

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IP4
Semiclassical Computation of High Frequency Waves in Heterogeneous Media

We introduce semiclassical Eulerian methods that are efficient in computing high frequency waves through heterogeneous media. The method is based on the classical Liouville equation in phase space, with discontinous Hamiltonians due to the barriers or material interfaces. We provide physically relevant interface conditions consistent with the correct transmissions and reflections, and then build the interface conditions into the numerical fluxes. This method allows the resolution of high frequency waves without numerically resolving the small wave lengths, and capture the correct transmissions and reflections at the interface. This method can also be extended to deal with diffraction and quantum barriers. We will also discuss Eulerian Gaussian beam formulation which can compute caustics more accurately.

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CP1

Disordered Beam Propagation in a Focusing Nonlinear Medium

We calculate both analytically and numerically the probability distribution for the intensity of a disordered optical beam propagating in a focusing media within the framework of the 1+1 Nonlinear Schrodinger equation. The far field intensity pattern is formed by a random number of interfering optical solitons with random parameters. We obtain the statistics of these parameters (and hence the field intensity distribution) via the disordered Zakharov-Shabat eigenvalue problem.

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CP1

Nonlinear Dynamics and Normal Forms in the Time Dependent Nonlinear Schrodinger/Gross Pitaevskii Equations

We consider the nonlinear dynamics of solutions to the NLS/GP equations with potential supporting three or four linear bound states. We compute and prove the existence of previously-unreported periodic orbits and routes to chaos in an ODE model problem. Normal forms are computed using Lie transforms, and the finite-dimensional solutions are shown to be shadowed by solutions to NLS/GP. Comparisons are made to NLS trimer and tetramer problems.

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CP1

Adaptive Construction of Surrogates for Parameter Inference in Nonlinear Wave Equations

Surrogate models are often used to accelerate Bayesian inference in computationally intensive systems. Yet the construction of globally accurate surrogates can be prohibitive and in a sense unnecessary, as the posterior distribution typically concentrates on a small fraction of the prior support. We present a new adaptive approach that uses stochastic optimization (the cross-entropy method) to construct surrogates that are accurate over the support of the posterior distribution. The method is then applied to parameter inference in nonlinear wave equations.

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CP1

Crosstalk Dynamics of Optical Solitons in Broadband Optical Waveguide Systems

We investigate the dynamics of soliton parameters in broadband optical waveguide systems, induced by energy and momentum exchange (crosstalk) in pulse collisions. Using single-collision analysis along with collision rate calculations, we show that dynamics of soliton amplitudes in N-channel waveguide systems can be described by N-dimensional Lotka-Volterra models. By finding the equilibrium states of these models and analyzing their stability, we are able to obtain ways for achieving stable transmission with equal nonzero amplitudes in all channels.

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CP1

Nonlinear Refraction Versus Solitonic Fission in Optical Lattices

Within the nonlinear Shrödinger equation we consider the soliton beam passing through the periodic or random optical lattice. We address how the lattice shape and geometry affect the refraction of the soliton. It is shown that the soliton-wave interference can play an important role in determining the refraction type. Then we demonstrate that the interplay between the beam refraction and reflection can bring about the splitting of a single coherent state into two ones.

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CP1

Chaos Control in a Transmission Line Model

We present a model of an electromagnetic system consisting of a transmission line oscillator coupled to terminating nonlinear electrical boundary components. Using the method of characteristics spatio-temporal chaos is observed. A chaos control method is presented, that uses small parameter perturbations to adjust the resistance at one of the boundaries. The control is based on a Poincare section technique that does not require a fully developed simulation in time.

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CP1

Josephson Oscillations in Dissipative Optical Systems

We have studied Josephson oscillations in an active fully optical system with defocusing Kerr nonlinearity. The considered system consists of a lasing cavity emitting photons into a waveguiding structure having strong but narrow variation of the refractive index. It has been shown that Josephson-like oscillations appear in the system when the flux though the barrier exceeds the threshold value. Different regimes of the oscillations have been studied thoroughly.

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CP2

Envelope Quasi-Solitons in Dissipative Systems with Cross-Diffusion

We consider two-component nonlinear dissipative spatially extended systems of reaction-cross-diffusion type. Previously, such systems were shown to support "quasi-soliton' pulses, which have fixed stable structure but can reflect from boundaries and penetrate each other. Presently we demonstrate a different type of quasi-solitons, with a phenomenology resembling that of the envelope solitons in Nonlinear Schroedinger equation: spatiotemporal oscillations with a smooth envelope, with the velocity of the oscillations different from the velocity of the envelope.

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CP2

Evolution of Spiral and Scroll Waves of Excitation in a Mathematical Model of Ischaemic Border Zone

We use asymptotics based on response functions to predict dynamics of re-entrant excitation waves in a moving boundary of a recovering ischaemic cardiac tissue, due to gradients of cell excitability and cell-to-cell coupling, and heterogeneity of individual cells. In three spatial dimensions, theory predicts conditions for scrolls to escape into the recovered tissue, where they are either collapse or develop fibrillation-like state, depending on filament tension. We confirm these predictions by direct simulations.

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CP2

Perturbed Magnetic Droplet Solitons

The Landau-Lifshitz equation with uniaxial anisotropy in one and two spatial dimensions admits a two-parameter family of solitary wave solutions called magnetic droplets. Physically relevant perturbations due to weak damping, a slowly varying external magnetic field, and spin torque are considered in the context of soliton perturbation theory. A dynamical systems analysis of the modulation system and direct numerical simulations of the governing PDE demonstrate that physical droplets can be nucleated, accelerated, and controlled.

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CP2

Amplification of Synaptic Inputs by Dendritic Spines

Dendritic spines are the site of contact for the majority of excitatory synapses in the mammalian brain, and as a result are the first step in the signaling between dendritic inputs and neuronal actional potential output. In this combined theoretical and experimental study, it is demonstrated that spines provide a uniformly high impedance compartment across the dendritic arbor that amplifies local depolarization. This spine amplification increases nonlinear voltage-dependent conductance activation and promotes electrical interaction among coactive inputs, enhancing neuronal response.

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CP2

Impact of Randomness on Solitary Wave Propagation in Granular Systems

We study the effect of randomness on the propagation of solitary waves in granular media composed of spherical particles. Randomness in grain properties and size is considered. The study shows the presence of two regimes of decay in peak force and kinetic energy, and a gradual transfer from potential to kinetic energy of the system. In 2D square packed systems, we also investigate the anisotropy of the randomness induced decay.

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CP2

Target Detection in Non-Uniform Slowness Fields Using Time-Reversed Nonlinear Solitary Waves

Radar problems include propagation of short waves with large scale realistic effects, such as refraction by complex slowness fields. Our approach is based on dissipative nonlinear solitary waves centered on wave centroid surfaces, which propagate on characteristics. This approach allows efficient propagation both forward in time, and backward in time (for target and source detection). Unlike ray tracing in complex domains, there do not appear to be any multiparticle chaotic effects.

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CP3

Solitons in Dipolar Bose-Einstein Condensates with Trap and Barrier Potential

The propagation of solitons in dipolar BEC in trap potential with a barrier potential is investigated. The regimes of soliton transmission, reflection and splitting in dependence on the ratio between the local and dipolar nonlocal interactions are analyzed analytically and numerically. The conditions for a fusion of splitted solitons are found. In addition the delocalization transition governed by strength of the nonlocal dipolar interaction is presented.

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CP3

Steady Structures and Rheology of Active Complex Fluids

Bacteria suspensions, active gels and assemblies of motors and filaments are active complex fluids which differ from their passive counterparts in that particles absorb energy and generate motion. They are interesting from a more fundamental perspective as their dynamic phenomenons are both physically fascinating and potentially of great biological significance. In this talk, I will present a continuum model for such systems. Hydrodynamics, stability and rheology will be discussed.

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CP3

Propagation of a Constant Velocity Fission Wave

The mechanism for the formation of a fission wave is simple: a large cylinder of fertile material is subjected to a neutron source at one end. The neutrons transmute material downstream and produce plutonium, which itself undergoes fission and produces neutrons. If the conditions are right, a self-sustaining reaction wave would form. Numerical studies have shown that waves of this type are possible. We have now derived an exact solution for the propagation velocity of these waves and show that these waves fall into a class of traveling wave phenomena encountered in other systems. The results are confirmed numerically.

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CP3

Rogue Waves in Plasmas

Rogue waves (freak waves) are space- *and* time-localized extreme events, recently arising as a paradigm in various fields. The occurrence of such excitations in charged matter (plasmas) is investigated, from first principles. A multiscale technique for the derivation of a nonlinear Schrödinger (NLS) model for plasma waves is adopted, and the result is analyzed, in terms on intrinsic plasma parameters. A set of exact solutions of the NLS equation has been argued to provide a plausible model for rogue waves in the ocean. These include rational solutions, the Ma breather, the Akhmediev breather and the Peregrine soliton. We review the properties of these solutions, and investigate their occurrence and relevance in plasmas. Our research covers both electrostatic and electromagnetic modes, and provides a self-contained framework for future investigations of the dependence of such modes on intrinsic plasma properties.

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CP3

A Characterization of Dispersive Shock Waves in the Magma Equation

In 1-D and under reasonable simplifications and assumptions, the full governing equations of subterranean vertical magma transport reduce to a degenerate nonlinear dispersive partial differential equation for the porosity ϕ of the form: $\phi_t + (\phi^n)_z - (\phi^n(\phi^{-m}\phi_t)_z)_z = 0$, where n, m are physically derived parameters. For an arbitrary initial step and physical parameter values, the properties of magma dispersive shock waves (speeds, leading amplitude) are constructed asymptotically. Results are corroborated by comparisons with an accurate pseudospectral numerical code for long-time integration.

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CP3

On Seismic Wave in Magnetoelastic Low Velocity Crustal Layer

We aim to study the propagation pattern of shear type waves or G-type waves in magnetoelastic crustal layer which is highly anisotropic in nature. The layer has been taken self-reinforced which is lying over a heterogeneous semi-infinite medium. B. Gutenberg investigated this special class of waves in low velocity zone between the Earth crust and upper mantle. Along with the period equation Condition for a large amount of energy to be confined near the surface has been obtained. We observed that a large portion of energy can flow along the interface for horizontally polarized shear waves with group velocity lower than the shear wave velocity in the upper mantle. Effects of reinforcement, magnetoelastic coupling parameter and inhomogeneity on the phase velocity of shear wave have been obtained separately and depicted by means of graphs. The surface plot of group velocity is drawn for wave number and depth parameter.

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CP3

Radiation by Superfluid Vortices in the Lighthill Regime

On hydrodynamic length scales, quantized superfluid vortices are commonly modeled as a system of coreless point vortices in 2D, or vortex filaments in 3D, whose motion is determined classically through the Biot-Savart law. Yet it is well known that a microscopic model that can describe the motion of quantized vortices exists in the form of Gross-Pitaevskii (GP) equation which captures the structure of the vortices within the healing layers. This model has been successfully tested in predicting vortex dynamics in Bose-Einstein condensates. In this work, we consider the asymptotic regimes under which point vortex dynamics is recovered from the GP equation. We show that the regime under which this occurs corresponds to the so-called Lighthill regime for evaluating the acoustic radiation in a classical fluid. We, therefore, formulate a corresponding theory of radiation that specifies the sound emitted by the motion of quantized vortices in the limit of low Mach number or equivalently large inter-vortex separation. We demonstrate our theoretical predictions with numerical simulations of the GP equation.

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CP4

Local Absorbing Boundary Conditions for Nonlinear Wave Equation on Unbounded Domain

The numerical solution of nonlinear wave equation on unbounded spatial domain is considered. The articial boundary method is introduced to reduce the nonlinear problem on unbounded spa- tial domain to an initial boundary value problem on a bounded domain. Using unied approach, which is based on operator splitting method, we construct the ecient nonlinear local absorbing boundary conditions for the nonlinear wave equation, and give the stability analysis of the re- sulting boundary conditions. Finally, several numerical examples are given to demonstrate the eectiveness of our method. (This talk is based on the joint work with Prof. Xiaonan Wu and Dr. Jiwei Zhang.)

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CP4

A Discontinuous-Galerkin Spectral Wave Model

Spectral wind-wave models have successfully been used in the ocean for many different applications. We implement a new numerical modeling approach using a discontinuous-Galerkin method in both geographic and spectral space. This allows us to have an unstructured-triangulation in geographic space and a structured spectral space with the ability to use higher-order approximations when needed. We verify and validate the model on test bed cases and achieve higher accuracy when using higher-orders in spectral space.

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CP4

Numerical Modeling of Internal Waves Generated by Turbulent Wakes Behind Towed Bodies in Stratified Media

Numerical models of an internal waves generated by wakes in stratified fluids have been presented. The calculation results show that the wake's excess momentum of order of from the total momentum in drag wake has a weak influence on the internal waves and on the turbulent energy decay. As in the case of a homogeneous fluid, a more significant influence of total excess momentum on the axis value of the defect of the longitudinal velocity component was observed.

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CP4

Compatible Numerical Scheme for the Linear Inertial Waves

A compatible numerical model based on a discontinuous

Galerkin FEM discretisation that preserves the Hamiltonian structure of the linear rotating Euler equations is presented. Thus, it conserves the important properties of the PDEs. Dirac theory is applied to derive the incompressible limit of the compressible Euler or acoustic equations which are used as a starting point in the numerical discretisation. Several test cases will be presented to assess the quality of the numerical model.

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CP4

A Coupled Boundary-Integral/Level-Set Method for Eigenvalue Optimization Problems

Eigenvalues are ubiquitous in describing wave phenomena and thus constrained eigenvalue optimization problems naturally arise when one seeks to control such phenomena. We study a new, coupled boundary-integral/level-set computational method which demonstrates greater accuracy over previously used methods while maintaining the capability of handling topological changes. Results for several shape and structural eigenvalue optimization problems are discussed, including Krein's problem on finding the density distribution of a membrane which extremizes the k-th Dirichlet-Laplacian eigenvalue.

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CP4

Numerical Solutions of Two-Way Propagation of Nonlinear Dispersive Waves Using Radial Basis Functions

In this talk we obtain the solutions of a Boussinesq system for two-way propagation of nonlinear dispersive waves by using the meshless method based on collocation with radial basis functions. The system of nonlinear partial differential equation is discretized in space by using these functions. The discretization leads to a system of coupled non-linear ordinary differential equations. These equations are then solve by using an Adam-Bashforth scheme. The method is tested for exact solitary solutions to these equations. In addition four conserved quantities are calculated numerically. The numerical results show excellent agreement with the analytical solution and calculated conserved quantities.

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CP5

Fractional Partial Differential Equations Driven by Fractional Gaussian Noise

Some fraction parabolic partial differential equations driven by fraction Gaussian noise are considered. Initial-value problems for these equations are studied. Some properties of the solutions are given under suitable conditions and with Hurst parameter less than half.

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CP5

Semicommutative Operators Associated with Dirac Operator and Darboux Transformation

We clarify a class of differential operators which are semicommutative with the 1-dimensional Dirac operator P defined by $P = i\sigma_2(d/dx) + \sigma_1 v(x)$, where σ_1, σ_2 are Pauli matrices. Such results are already known for the 1-dimensional Schrödinger operator $H = -(d/dx)^2 + u(x)$. We extend these results to the Dirac operator P. As a result, we obtain the interesting formula related to the Darboux ransformation. Moreover, a new algebraic scheme for solving the eigenvalue problem associated with the Dirac operator P is obtained.

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CP5

Interaction Properties Of Complex Solitons For The Hirota MKdV Equation

The Hirota-mKdV equation has general complex 1-soliton solutions that describe solitary waves with time-varying phase. We use Hirota's bilinear formalism to find the general complex 2-soliton solution. This solution describes a collision in which a fast soliton over takes a slow soliton. By an asymptotic analysis we show that collisions produce a shift in both the position and the phase of the fast and slow solitary waves. We observe several types of interactions during the collision depending on the speeds and phase angles of the fast and slow solitons.

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CP5

Stability of Solitary Waves for the Vector Nonlinear Schroedinger Equation in Higher-Order Sobolev Spaces

In this talk, a sharp form of orbital stability for the

Schrödinger system, also known as the vector NLS,

$$i\frac{\partial}{\partial t}u_j + \frac{\partial^2}{\partial xx}u_j + 2\sum_{i=1}^{m}|u_i|^2u_j = 0,$$

where u_j are complex-valued functions of $(x,t) \in R^2$, $j = 1, 2, \ldots, m$, is presented in L^2-based Sobolev classes of arbitrarily high order. The result means practically that not only does the bulk of what emanates from the perturbed solitary wave stay close in shape and propagation and phase speeds to the original solitary wave, but emerging residual oscillations must also be very small and not only in the energy norm.

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CP5

Vanishing Viscosity Limit for An Optimal Control Problem of Scalar Conservation Laws in the Presence of Shocks

To reduce the computational cost for optimal control problems of the inviscid Burgers equation in the presence of shocks, Zuazua et al. have developed an alternating descent method, and revisited it by the method of vanishing viscosity. In the present work, we study theoretically the vanishing viscosity limit of such a problem for 1-D scalar conservation laws with a single shock or finite many non-interacting shocks. We employ the method of matched asymptotic expansions to construct approximate solutions to the smoothed nonlinear, the linearized and the dual problems, respectively. It is then proved that the approximate solutions satisfy the corresponding equations asymptotically, and converge to the solutions of the corresponding inviscid problems with certain rates. The discontinuities of coefficients in those equations, especially the inverse dual equation, lead to difficulties when taking the limits. The equations for the shock and the variation of its position are also derived.

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CP5

Stability of Traveling Waves for Systems of Nonlinear Integral Recursions in Spatial Population Biology

We use spectral methods to prove a general stability theorem for traveling wave solutions to the systems of integrodifference equations arising in spatial population biology. We show that non-minimum-speed waves are exponentially asymptotically stable to small perturbations in appropriately weighted L^∞ spaces, under assumptions which apply to examples including a Laplace or Gaussian dispersal kernel a monotone (or non-monotone) growth function behaving qualitatively like the Beverton-Holt function (or Ricker function with overcompensation), and a constant probability $p \in [0, 1)$ (or $p = 0$) of remaining sedentary for a single population; as well as to a system of two populations exhibiting non-cooperation (in particular, Hassell and Comins' model) with $p = 0$ and Laplace or Gaussian dispersal kernels which can be different for the two populations.

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CP5

Stability of Solitons in PT-Symmetric Nonlinear Potentials

We consider stationary localized modes $q(\xi,\eta) = e^{ib\xi}w(\eta)$ of the nonlinear Schrodinger equation $iq_\xi = -q_{\eta\eta} - [1 + iW(\eta)]|q|^2q$, where $W(\eta)$ is an odd function. We report continuous families of the nonlinear modes, which can be parametrized by the propagation constant b. We investigate linear stability of the modes computing the Evans function of the corresponding linear operator. Our analysis shows that for $\sigma \ll 1$ the localized modes for $W(\eta) = \sigma \sin\eta$ and $W(\eta) = \sigma \tanh\eta$ become unstable when b is below a certain threshold value. However, this threshold disappears for $W(\eta) = \sigma\eta$.

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CP6

Inertial Waves in a Rapidly Rotating Cylinder

Rapidly rotating flows can support waves with peculiar properties. In the inviscid limit, the equations for infinitesimal disturbances about solid-body rotation reduce to a hyperbolic problem for disturbance frequencies less than twice the background rotation rate, the characteristics of which represent discontinuities in the velocity or its gradient. In real life, these are regularized by viscosity, resulting in the observed inertial waves. We explore numerically the consequences of finite viscosity and nonlinearity on such flows.

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CP6

Have You Seen Our Water Waves?

When water flows past an obstruction such as a ship or a step in a channel, waves are often produced behind or ahead of the disturbance. Recently, techniques in exponential asymptotics have allowed us to predict the theoretical existence of new classes of gravity-capillary waves. These waves have never been seen before – in nature or in the digital world. Do they truly exist? Come and decide for yourselves!

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MS1

On the Stability of Some Periodic Waves Arising in the Kawahara Equation

The Kawahara equation is a weakly nonlinear model for capillarity-gravity water waves which admits solitary-wave type solutions. For each solitary wave, there exists a family of periodic waves which is asymptotic to the solitary wave when the period tend to infinity. In this talk we study the stability of these periodic waves.

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MS1

Viscosity-induced Instability for Euler and Averaged Euler Equations in a Circular Domain

We consider the infinite time behaviour of a family of stationary solutions of Euler's equation, which can be described as constrained minima of energy on level sets of enstrophy. For free boundary conditions, this family shadows solutions of 2D Navier-Stokes equations. However, under the no-slip and under the Navier-slip boundary conditions and in a circular domain, the infinite time Navier-Stokes evolution orbit of a starting point on the family of constrained mimina has order 1 distance to the family, however small the viscosity is. The viscosity in the Navier-Stokes equations is a singular perturbation for Euler's equation and one might suspect that the viscosity-induced instability is related to this singularity. This is not the case: we show that the same phenomenon can be observed for the averaged Euler equations and second grade fluids with Navier-slip boundary conditions in a circular domain.

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MS1

Relaxed Variational Principle for Water Wave Modeling

A new method, based on a relaxed variational principle, is presented for deriving approximate equations for water waves. It is particularly suitable for the construction of approximations. The advantages will be illustrated on numerous examples in shallow and deep water. Using carefully chosen constraints in various combinations, several model equations are derived, some being well-known, others being new. These models are studied analytically, exact travelling wave solutions are constructed, and the Hamiltonian structure unveiled.

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MS1

A New Model of Roll Waves: Comparison with Brock's Experiments

We derive a mathematical model of shear flows for shallow water flowing down an inclined plane. Periodic solutions to this model describing roll waves were obtained. The solutions are in good agreement with the experimental profiles of roll waves measured in Brock's experiments. In particular, the height of the vertical front of the waves, the shock thickness and the wave amplitude are well captured by the model.

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MS1

Geometric Integration for Damped Hamiltonian PDEs

A general framework for constructing numerical methods that exactly preserve dissipative properties of damped Hamiltonian PDEs is presented in detail. These methods are compared analytically and numerically to standard conservative methods, which generally destroy the actual dissipation rates but do retain other advantages in the dissipative context. Semi-linear wave equations and nonlinear Schrodinger equations, both with added dissipation, are used as examples to demonstrate the long-time behavior of the numerical solutions.

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MS2

Asymptotic Methods for Multi-scale Solitary Waves in Periodic Media

Gap solitary waves in a one-dimensional periodic lattice are studied for the case that the solitary wave spans a large number of lattice periods. In this limit, an analytical theory utilizing exponential asymptotics is presented, that reveals the bifurcation of a countable set of solitary-wave families. The stability properties of certain of these solution families are also discussed, and the analytical predictions are compared against numerical results.

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MS2

Light Localization in Specially Designed Photonic Lattices

Optically-induced photonic lattices have served as an ideal platform for exploring discretizing light behaviors. In this talk, we provide a brief overview of our recent work on spatial control of light propagation in specially-designed photonic lattices established by the optical induction technique. In particular, we present our experimental results on controlled Bragg reflection and anomalous diffraction/refraction in ionic-type lattices, surface localization and edge states in photonic superlattices and honey-comb lattices, image transmission through 3D photonic lattices with engineered coupling, along with recent results on disordered lattices.

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MS2

Multivortex Discrete Solitons in Coupled Nonlinear Waveguides and Photonic Lattices

We introduce discrete solitons with globally linked multiple vortices in a ring of nonlinear oscillators coupled to a central site. The system is described by the nonlinear Schroedinger equation and supports a variety of multivortex solitons with complex phase structures. We study these multivortex solitons and determine their stability analytically and numerically. We show that these solitons may be perturbed to produce stable "breather' states with novel vortex dynamics, such as coordinated charge flipping and vortex spiraling.

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MS2

Nonlinear Modes in Finite-dimensional PT-symmetric Systems

Linear parity-time symmetric lattices below the point of the symmetry breaking posses pure real spectra. Such models can be reduced by a unitary transformation either to Hamiltonian systems or to dissipative systems not obeying the symmetry but still having pure real spectrum (termed pseudo-Hermitian). This property, valid for linear systems does not hold when the nonlinearity is taken into account. While Hamiltomian and PT symmetric lattices allow for existence of the continuous branches of the solutions, the pseudo-Hermitian models allow for existence of only a discrete set of the localized modes. The stability properties of localized modes in theses three types of the lattices also show significant differences. Comparative analysis of the properties of the nonlinear modes will be reported.

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MS2

Stability Analysis of Solitons in PT Symmetric Lattices

Parity-time (PT)-symmetric potentials are complex potentials in the Schrödinger equation whose real and imaginary parts are symmetric and anti-symmetric respectively. PT potentials have the surprising property that even though they contain gain and loss in the potential, the linear spectrum of the Schrödinger operator can still possess all-real eigenvalues, thus allowing solitons to exist over a continuous range of propagation constants in the presence of nonlinear effects. In this talk, we investigate the stability of solitons in PT-symmetric periodic potentials (optical lattices) in both one and two dimensional systems. First we show analytically that when the strength of the gain-loss component rises above a certain threshold (phase-transition point), an infinite number of Bloch bands turn complex simultaneously. Second, we show numerically that stable families of solitons exist in PT lattices. In one dimension the fundamental solitons in the semi-infinite gap remain stable up until the phase transition point, however, in higher bandgaps and higher dimensions we find that increasing the gain-loss component has a destabilizing effect on soliton propagation. The parameter range of stable solitons shrinks as new regions of instability appear. In fact, in two dimensions stable solitons only exist for a bounded set of propagation constants in the semi-infinite gap, even for very small imaginary components. Thirdly, we investigate the evolution of unstable solitons under perturbation.

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MS3

Space-time Statistics of Capillary Wave Turbulence

We report on the experimental observation of space-time resolved pure capillary wave turbulence. The wave system is studied experimentally with two immiscible ?uids of almost equal densities where capillary surface waves are excited by a low-frequency random forcing. The probability density function of the wave amplitude shows a quasi-Gaussian behavior and the power spectral density is shows a power-law behavior in frequency with a slope of α =-3.0 and in wave number with a slope β =-4.0. These results agree with theoretical predictions on Kolmogorov-Zakharov spectra and wave amplitude statistics for capillary waves.

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MS3
Non Linear Dynamics of Flexural Wave Turbulence

We report a direct measurement of the nonlinear timescale T_{NL} related to energy transfer in wave turbulence of flexion waves on a thin elastic plate. This time scale is extracted from the space-time measurement of the deformation of the plate by studying the temporal dynamics of wavelet coefficients of the turbulent field. We discuss the separation between the relevant time scales which is at the core of the weak turbulence theory.

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MS3
Wave Turbulence: A Story Far From Over

When is the wave turbulence closure valid and when is it not ? When are the Kolmogorov-Zakharov solutions valid and when are they not ? This talk will discuss these challenges.

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MS3
Can One Hear a Kolmogorov Spectra? Wave Turbulence on a Thin Elastic Plate

We study the long-time evolution of waves of a thin elastic plate in the limit of small deformation so that modes of oscillations interact weakly. According to the theory of weak turbulence (successfully applied in the past to plasma, optics, and hydrodynamic waves), this nonlinear wave system evolves at long times with a slow transfer of energy from one mode to another. A kinetic equation for the spectral transfer in terms of the second order moment is derived. We have shown that such a theory describes the approach to an equilibrium wave spectrum and represents also an energy cascade, often called the Kolmogorov-Zakharov spectrum. We have realized numerical simulations that confirmed this scenario moreover under some conditions a kind of "inverse cascade" may be observed.

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MS3
Wave Turbulence in Nonlinear Fiber Optics: Experiments and Theory

We present a theoretical and experimental study of the nonlinear propagation of partially incoherent optical waves in single mode optical fibers. We revisit the traditional treatment of the wave turbulence theory to provide a statistical kinetic description of the integrable scalar NLS equation. We theoretically and numerically show the existence of an irreversible evolution toward a statistically stationary state. We report the experimental observation of this peculiar relaxation process of the one dimension NLS equation.

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MS4
A Fast and Accurate Absorbing Boundary Condition for the Helmholtz Equation

Constructing accurate absorbing or radiating boundary conditions for the Helmholtz equation in heterogeneous media is difficult and costly. We propose here a general framework for rapidly constructing and evaluating ABC's by compressing the Dirichlet to Neumann map, using matrix probing. This fits the DtN map to a few well-chosen matrices and thus has greater potential for accuracy and flexibility in variable media. This can be used as precomputation for solving the wave equation multiple times.

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MS4
Dispersionless Time-domain PDE Solvers for High-frequency Problems and General Spatial Geometries

We present fast time-domain high-order PDE solvers that address some of the main difficulties associated with simulation of realistic scientific and engineering systems under high-frequency and nonlinearity. Based on a novel Fourier-Continuation (FC) method for the resolution of the Gibbs phenomenon, these solvers can deliver unconditional stability, essentially dispersionless numerics, high order accuracy and perfect parallel scaling for challenging linear and nonlinear problems involving high frequencies and general spatial domains.

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MS4
The Gaussian Beam Method for the Dirac Equation in the Semi-classical Regime

The Dirac equation is an important model in relativistic quantum mechanics. In the semi-classical regime $\epsilon \ll 1$, the best existing method time splitting spectral method [Z.Y. Huang, S. Jin, P.A. Markowich, C. Sparber and C.X. Zheng, A time-splitting spectral scheme for the Maxwell-Dirac system, Journal of Computational Physics, 208(2005), pp. 761-789.] require the mesh size to be $O(\epsilon)$, which makes the direct simulation extremely expensive. In this paper, we present the Gaussian beam method for such problem. With the help of suitable space decomposition technique, the Gaussian beams can be independently evolved and summed to constructed the solution of the Dirac equation efficiently and accurately. Moreover, the proposed Eulerian Gaussian beam keep the advantages of constructing the Hessian matrices by using level set functions' derivatives. Finally we test our method by several numerical examples.

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MS4
Frozen Gaussian Approximation for High Frequency Wave Propagation

We propose the frozen Gaussian approximation for the computation of high frequency wave propagation. It provides a highly efficient computational tool based on the asymptotic analysis on phase plane. Compared to geometric optics, it provides a valid solution around caustics. Compared to the Gaussian beam method, it overcomes the drawback of beam spreading. We will present several numerical examples as well as preliminary applications in geology to verify the performance of the method.

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MS4
Global Geometrical Optics Method

We develop a novel approach, named *global geometrical optics method*, for the numerical solution to wave equations in the high-frequency regime. The initial Cauchy data is assumed in the WKB form. The basic idea of this approach is to reformulating the governing equation in a moving frame, and deriving a globally valid WKB-type function with the aid of partition of unity. This WKB-type function is merely defined on the Lagrangian manifold induced by the Hamiltonian flow, and from which, the wave solution can be retrieved by a coherent state integral within first order accuracy. The merit of the proposed approach is manyfold. First, compared with the thawed Gaussian beam approaches, it presents an approximate wave solution with first order asymptotic accuracy uniformly, even around caustics. Second, compared with the canonical operator method, this approach does not require any a priori knowledge about the structure of Lagrangian manifold. Third, compared with the frozen Gaussian beam approaches such as Herman-Kluk semi-classical propagator method, the proposed approach involves an integral on a manifold of much lower dimension. We report numerical tests on both Schrödinger and Helmholtz equations.

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MS5
Coherent Structures, Transport and Invariant Manifolds in Unsteady Flows

Lagrangian coherent structures (LCSs) are ubiquitous in fluid flows at all scales, and are strongly influential in determining scalar transport in unsteady flows. This talk will outline theoretical, diagnostic and numerical issues related to characterizing both LCSs and consequent transport, and introduce the areas to be examined in more detail by the minisymposium speakers. Invariant manifolds (as defining LCSs) will also be addressed under general time-dependence, along with explicit examples in 2D and 3D.

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MS5
Data Mining Remotely Sensed Image Sequences and Transport Analysis of Spatiotemporal Dynamical Systems

Scientific fields, such as climatology, and oceanography produce large data sets from spatiotemporal video data as remotely sensed hyperspectral satellite data. Variational methods for image processing suited to complex dynamical systems typical of fluid dynamics, and the tools of dynamical systems such as transfer operators have not been brought to bear on data inferred directly from movies. We discuss modeling and transport analysis for remotely sensed ecological systems such as biological products including algae blooms.

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MS5

A Global Theory of Transport Barriers

We introduce a unified approach to locating transport barriers in general two-dimensional, non-autonomous dynamical systems. Using tools from continuum mechanics and differential geometry, we show that transport barriers can be obtained as minimal geodesics under an appropriate Riemannian metric induced by the Cauchy-Green strain tensor field. As such, transport barriers can be directly computed (as opposed to just indirectly observed) as solutions of classic Lagrangian or Hamiltonian equations of motion. We show how these results reveal previously undetected transport barriers with mathematical rigour in systems ranging from aperiodically forced models to satellite observations of the ocean.

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MS5

Lagrangian Coherent Structures and Eddy Diffusion

Lagrangian coherent structures (LCS) are known as the templates for chaotic mixing in nonlinear aperiodic dynamical systems, such as geophysical flows. In recent years, theoretical developments on the deterministic LCS have allowed the objective identification of mixing barriers and enhancers in geophysical flows. Stochastic transport associated with LCS, on the other hand, is less studied, partly due to the inherent scale separation between coherent structures and molecular diffusion. However, sub-grid scale uncertainty of geophysical flows cannot be neglected when one tries to quantify diffusive transport of substances. In this talk we will discuss some recent efforts on quantifying diffusive mixing associated with the LCS. In particular, eddy diffusivity tensors associated with advection-diffusion are constructed based on Lagrangian measures from LCS. Some archetypal examples will be discussed.

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MS5

Topological Detection of Coherent Structures

In many applications, particularly in geophysics, we often have fluid trajectory data from floats, but little or no information about the underlying velocity field. The standard techniques for finding transport barriers, based for example on finite-time Lyapunov exponents, are then inapplicable. However, if there are invariant regions in the flow this will be reflected by a 'bunching up' of trajectories. We show that this can be detected by tools from topology.

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MS6

Aggregation and Growth of Clusters During a Thermal Quench

The creation of clusters in the context of a quench is studied. Two model problems are considered. First, undersaturated vapor is cooled at a prescribed rate. After a time-lag, the nucleation rate rises exponentially. A short burst of nucleation decreases the super-saturation and ends the creation of new clusters. We find asymptotic descriptions of the resulting distribution of cluster sizes and the total amount of clusters generated. The time-lag is related to the quench rate by an implicit formula. Next, the flow of a warm gas onto a cold wall is examined. The creation and growth of clusters in the boundary layer next to the cold wall are the natural extension of the first problem. We find the total amount of clusters generated, the concentration of monomers in the gas and the size of the clusters as functions of the distance to the wall. We also determine the distance from the wall at which the nucleation happens, and the length of the "growth layer', during which the growth of clusters brings the gas to equilibrium.

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MS6

Branching Processes and Coagulation: Asymptotic Self-similarity for a Generalized Smoluchowski Equation

We investigate the asymptotic self-similarity of solutions to a new coagulation model arising in the theory of branching processes. Informally, the equation models a coalescence process with multiple interactions, where the size and number of interacting clusters are sampled randomly. Under a suitable regular variation assumption on the sampling measure, we characterize all nontrivial scaling limits of solutions. Our results include, as a special case, the scaling limits for the classical kernel $K(x, y) = 2$, previously studied by Menon and Pego, among others.

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MS6

Coagulation Dynamics Driven by Uniform Growth

We describe progress toward classifying initial data that lead to self-similar growth in a coagulation process that involves uniform growth of domains in one dimension. This is joint work with Jack Carr (Heriot-Watt University).

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MS6

Symmetry-breaking in Crystallisation

A significant stage in the formation of living systems was the transition from a symmetric chemistry involving mirror-symmetric chiral species into a system involving just one-handedness. We derive and analyse systems of coupled coagulation-fragmentation equations which describe crystal-grinding and exhibit symmetry-breaking, with the

aim of elucidating those mechanisms responsible for the bifurcation. The talk will cover and hopefully extend work published in Orig Life & Evol Biospheres, 41, 133–173. (2011).

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MS6

Coagulation Equations with Nonhomogeneous Kernels

Coagulation processes are to be found everywhere in nature: from the coalescence of aerosols and polymers on the microscopic scale to the coalescence of water to form hail stones on the macroscopic scale to the formation of planets and stars on the cosmic scale. The earliest equation to model coagulation processes was derived by Smoluchowski in 1916. The Smoluchowski coagulation equation, along with various extensions and generalizations, have been widely studied. While the general coagulation process, namely the coming together of small particle clusters to form larger particle clusters, are common, the physics governing the coalescence of aerosols and the formation of planets is undoubtedly very different. These physical differences are manifested in the particular coagulation kernel that is assumed in the coagulation equation. In their quest to understand symmetry in coagulation processes, mathematicians and physicists have attempted to find self-similar solutions to Smoluchowski's coagulation equation. When looking for self-similar solutions, it is natural to consider homogeneous coagulation kernels. In this talk I hope to show that some interesting phenomena can be found by considering non-homogeneous coagulation kernels.

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MS7

Spectral Stability of Shock Layers in Compressible Fluid Flow

We review the recent developments in our group's study on the stability theory for high Mach number viscous shock layers in multi-D compressible fluid flow, as well as detonation waves in reactive flow. In particular, we discuss the substantial challenges observed when computing the Evans function in Eulerian coordinates at high frequencies. We then show how we can overcome these problems by transforming into canonical and somewhat general coordinates. The results are surprising.

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MS7

Horseshoes and Hand Grenades: On Standing Waves in a Gross-Pitaevskii Equation

We look for standing waves in NLS-type equations with a periodic or N-well potential – a popular model for optical propagation and Bose-Einstein condensation. We simplify a shooting strategy by detailing the construction of a horseshoe map. The geometry of the horseshoe varies with the nonlinearity (attracting, repulsive or competing), yet in each case we instantly identify a huge assortment of standing waves. Finally, we discuss how to quickly recover stability information encoded within the horseshoe.

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MS7

Stability of Solitons Traveling on Vortex Filaments

In this work, we develop a general framework for studying the linear stability of soliton solutions of the vortex filament equation (VFE), based on the correspondence between the VFE and the nonlinear Schrodinger (NLS) equation provided by the Hasimoto map. In particular, we show that the one-soliton solutions of the VFE are linearly stable, which is in agreement with the numerical results obtained by Kida in 1982. Furthermore, it is shown that a similar result hold for the planar VFE. In the planar case, the filament equation is related to the integrable modified Korteweg-de-Vries Equation.

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MS7

Nonlinear Eigenvalues, Keldysh's Theorem, and the Evans Function

We consider eigenvalue problems for nonlinear Fredholm operator pencils, and show how to count and localize them using contour integrals and an abstract Keldysh Theorem. For pencils of differential operators, this allows one to count the number of zeros of the Evans function by solving boundary value problems on finite intervals.

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MS7

Fredholm Determinants and Computing the Sta-

bility of Travelling Waves

We are concerned with the computation of spectra of linear operators; in particular with large scale and multi-dimensional non-selfadjoint spectral problems. We present a a general class of multi-dimensional shooting algorithms for computing on Grassmann manifolds, developed by Ledoux, Malham and Thümmler and Ledoux, Malham, Niesen and Thümmler, for this purpose. Further, Ledoux, Malham and Marangell have revealed there is a relation between singularities in the Grassmann to chart Riccati flow and isolated eigenvalues. This is because the Riccati flow generalizes the Weyl–Titchmarsh function in one spatial dimension. In more than one spatial dimension, in terms of the infinite dimensional Fredholm (or Sato) Grassmannian, the operator Riccati flow represents the Dirichlet to Neumann map. If there is time we will try to relate this work to that of Deng and Jones on the Morse/Maslov index for selfadjoint multi-dimensional elliptic operators and also consider connections to Fredholm determinants by Bornemann and Karambal.

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MS8

Loops of Energy Bands for Bloch Waves in Optical Lattices

We will consider Stationary Bloch waves of Bose-Einstein condensates in an optical lattice via the Gross-Pitaevskii equation. This talk will be devoted to the bifurcation of stationary states which manifests itself as loops in the energy bands of the Bloch waves. In particular, the bifurcation is shown to be a supercritical pitchfork bifurcation. Analytical results will be illustrated by numerical computations.

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MS8

Stability of Solutions to a Non-local Gross-Pitaevskii Equation with Applications to Bose-Einstein Condensates

The Gross-Pitaevskii equation is a common model in physics, but it only takes local interactions into account. This paper demonstrates the validity of using a nonlocal formulation as a generalization of the local model. A large class of nonlocalities and potentials is studied. We then establish the orbital stability of a class of parameter-dependent solutions to the nonlocal problem. Numerical results corroborate the analytical stability results.

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MS8

Existence, Stability and Dynamics of Solitary Waves in Local and Nonlocal Discrete Nonlinear Schrodinger and Klein-Gordon Lattices

In this talk, we will review a number of results obtained over the last few years in equations of the discrete nonlinear Schrodinger and of the Klein-Gordon type. In the former class of models, we will consider the existence, stability and dynamics of standing waves and in the latter of time-periodic, exponentially localized discrete breather solutions for mostly local but also nonlocal models.

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MS8

Dark Solitons and Soliton Complexes in Nonlocal Dissipative Systems

Abstract not available at time of publication.

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MS8

The Cauchy Problem and Traveling Waves for a Nonlocal Gross-Pitaevskii Equation

We study the Gross-Pitaevskii equation involving a nonlocal interaction. Our aim is to give sufficient conditions that cover a variety of nonlocal interactions such that the associated Cauchy problem is globally well-posed with nonzero boundary condition at infinity. We focus on even potentials that are positive definite or positive tempered distributions. We also provide sufficient conditions such that there exists a range of speeds in which nontrivial traveling waves do not exist.

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MS9

The Reduced Ostrovsky Equation: Integrability and Breaking

The reduced Ostrovsky equation is a modification of the Korteweg-de Vries equation, in which the usual linear dispersive term with a third-order derivative is replaced by a linear non-local integral term, which represents the effect of background rotation. This equation is integrable provided a certain curvature constraint is satisfied. We demonstrate, mainly through numerical simulations, that when this curvature constraint is not satisfied at the initial time, then wave breaking inevitably occurs.

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MS9

Transverse Spectral Stability of Periodic Waves

The Kadomtsev-Petviashvili (KP) equation possesses a four-parameter family of one-dimensional periodic traveling waves. We study the spectral stability of the waves with small amplitude with respect to two-dimensional perturbations which are either periodic in the direction of propagation, with the same period as the one-dimensional traveling wave, or non-periodic (localized or bounded). We focus on the so-called KP-I equation (positive dispersion case), for which we show that these periodic waves are unstable with respect to both types of perturbations. Finally, we briefly discuss the KP-II equation, for which we show that these periodic waves are spectrally stable with respect to perturbations which are periodic in the direction of propagation, and have long wavelengths in the transverse direction.

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MS9

Generalized Multi-symplectic Integrators for a Class of Hamiltonian Nonlinear Wave PDEs

Focusing on the dissipative effect of a class of PDEs with small damping in the Hamiltonian setting, a new theoretical framework named generalized multi-symplectic integrator is proposed, extending the concept of multi-symplectic PDEs to the non-conservative setting. To test the idea, several numerical experiments on the compound KdV-Burgers equation are carried out. The numerical results illustrate that the generalized multi-symplectic integrator is structure-preserving and can reproduce the dissipative effect of the non-conservative system.

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MS9

The Morse and Maslov Indices for Periodic Problems

For Hill's equations with matrix valued periodic potential, we discuss relations between the Morse index, counting the number of unstable eigenvalues, and the Maslov index, counting the number of signed intersections of a path in the space of Lagrangian planes with the train of a plane.

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MS9

Statics and Dynamics of Atomic Dark-bright Solitons in the Presence of Localized Impurities

Adopting a mean-field description for a 2-component atomic Bose-Einstein condensate, dark-bright solitons are studied in the presence of impurities. We use adiabatic perturbation theory and show that, counter intuitively, an attractive (repulsive) delta-like impurity induces an effective localized barrier (well) in the effective potential felt by the soliton; this way, dark-bright solitons are reflected from (transmitted through) attractive (repulsive) impurities. Analytical results for the small-amplitude oscillations are found to be in good agreement with results obtained via a Bogoliubov-de Gennes analysis and direct numerical simulations.

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MS10

Stabilizing 1D Solitons Against the Critical Collapse by Quintic Nonlinear Lattices

It has been recently discovered that stabilization of two-dimensional (2D) solitons against the critical collapse in media with the cubic nonlinearity by means of nonlinear lattices (NLs) is a challenging problem. We address the 1D version of the problem, i.e., the nonlinear Schrödinger equation with the quintic or cubic-quintic (CQ) terms, the coefficient in front of which is periodically modulated in space. Stability diagrams for the solitons are produced by means of numerical methods and analytical approximations. It is found that the sinusoidal NL stabilzes solitons supported by the quintic-only nonlinearity in a narrow stripe in the parameter plane, on the contrary to the case of the cubic nonlinearity in 2D, where the stabilization of solitons by smooth spatial modulations is not possible at all. The stability region is much broader in the 1D CQ model, where higher-order solitons may be stable too. Publication: J. Zeng and B. A. Malomed, Phys. Rev. A 85, 023824 (2012).

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MS10

Linear and Nonlinear Properties of Strained Photonic Crystals

Perhaps the two most important properties of photonic crystals are (1) its photonic band gap, which allows for strong light confinement and very efficient lasing, and (2) its ability to strongly increase the density-of-states, enhancing nonlinear effects. Here, we show that an inhomogeneous strain in a periodic two-dimensional photonic crystal structure acts to induce an effective magnetic field near the Brillouin zone corners. This field in turn induces a complete photonic band gap and gives rise to Landau levels: highly degenerate energy levels with correspondingly high density-of-states. These Landau levels lead to enhancement of nonlinear effects (such as harmonic generation). We show the presence of both defect modes and edge modes within the band gap (which lies in between the Landau levels). Experiments are currently on their way, using a silicon-on-insulator photonic crystal slab system.

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MS10

Multi-site Breathers in Klein–Gordon Lattices: Stability, Resonances, and Bbifurcations

We prove the most general theorem about spectral stability of multi-site breathers in the discrete Klein–Gordon equation with a small coupling constant. In the anti-continuum limit, multi-site breathers represent excited oscillations at different sites of the lattice separated by a number of "holes" (sites at rest). The theorem describes how the stability or instability of a multi-site breather depends on the phase difference and distance between the excited oscillators. Previously, only multi-site breathers with adjacent excited sites were considered within the first-order perturbation theory. We show that the stability of multi-site breathers with one-site holes change for large-amplitude oscillations in soft nonlinear potentials. We also discover and study a symmetry-breaking (pitchfork) bifurcation of one-site and multi-site breathers in soft quartic potentials near the points of 1:3 resonance.

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MS10

Stability Analysis of Solitary Waves Near Bifurcation Points in Generalized Nonlinear Schrodinger Equations

Stability properties of solitary waves near bifurcation points in the generalized nonlinear Schrodinger equations with arbitrary potentials are analyzed. First, conditions for three major types of solitary-wave bifurcations, namely saddle-node bifurcations, pitchfork bifurcations and transcritical bifurcations, are derived. Second, we show that at a saddle-node bifurcation point, the stability of solitary waves does not switch. In particular, both branches of saddle-node bifurcations can be stable. This is in stark contrast with saddle-node bifurcations in finite-dimensional dynamical systems, where stability of the two branches always switches. Thirdly, we show that at a pitchfork bifurcation point, the continuous solitary-wave branch switches stability, while the stability of the two bifurcated branches is determined by the sign of their power slopes. Fourthly, we show that at a transcritical bifurcation point, both solitary-wave branches switch stability. Lastly, we use numerical examples to illustrate these analytical results.

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MS10

Nonlinear Diffraction and Interband Transitions in Photonic Graphene

Nonlinear diffraction and interband transitions in two-dimensional honeycomb lattices, in nonlinear optics sometimes termed photonic graphene, are studied analytically and numerically. The nonlinear diffraction of the Bloch wave envelope associated with so-called Dirac points where two linear dispersion surfaces touch each other develops a triangular pattern during propagation. This phenomenon is markedly different from conical diffractions which occurs in the leading order 'pure' Dirac system in which the diffraction pattern evolves circularly (i.e., conically). The triangular structure is related to the higher order dispersion relation of the homeycomb lattice which has trigonal warping behavior near the Dirac points. A higher-order nonlinear Dirac equation is then derived and used to describe the dynamics of the Dirac wave envelopes. Asymptotic analysis of the linear equations demonstrates the triangular diffraction as well as its decay rate and agrees with numerical simulations. Further, nonlinear analysis is employed to study the energy transitions between two nearby bands which touch at the Dirac point. The sign of the nonlinearity, focusing or defocusing, determines the direction of the triangular pattern. This is due to the preference of energy transitions from one band to another. Analytical results agree well with direct numerical simulations.

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MS11

Periodic Travelling Waves in Dimer Granular Chains

Bifurcations of periodic travelling waves in granular dimer chains are studied near the anti-continuum limit, when the mass ratio between the light and heavy beads is a small parameter. We show that each limiting periodic wave is uniquely continued with respect to the mass ratio parameter and the periodic waves with the wavelength larger than a certain critical value are spectrally stable. We also prove uniqueness of the continuation of periodic travelling waves that exist in the homogeneous granular crystals with respect to the mass ratio parameter. Numerical computations are developed to study connections between these two solution families, as well as bifurcations and instability onsets along each family.

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MS11

Highly Nonlinear Stress Waves in 2D Granular Crystals

Highly ordered granular systems, i.e. granular crystals, present a unique nonlinear dynamic behavior stemming from the Hertzian contact potential. We investigate the elastic stress wave propagation through uncompressed two-dimensional granular crystals with variable packing geometries. Experimental results are in good agreement with discrete particle model simulations. The unique dynamic properties of these crystals can be exploited to design granular systems with predetermined stress wave paths, which could be used as impact energy mitigating devices.

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MS11

Analytical Study of the Interaction of Solitary Waves with Defects in Granular Crystals

It is a well known fact that uncompressed, homogeneous granular chains support the propagating solitary wave solution earlier discovered by Nesterenko. In the present work we develop a systematic analytical approach to describe the interaction of Nesterenko solitary like pulses with various local and nonlocal structural in-homogeneities such as defects in nonlinear stiffness, masses of particles, inter-chain and on-site potentials. The developed analytical model is in a fairly good correspondence with the numerical simulations.

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MS11

Equipartition of Energy in Uncompressed Granular Crystals

Granular crystals are unique nonlinear systems that exhibit interesting properties stemming from the nonlinear contact interactions (Hertzian) between two individual particles. We study numerically and experimentally the dynamic effects of spherical interstitial particles placed between two adjacent uncompressed chains of larger particles. We excite one of the large particle chains with an impact and show energy transfer and equipartition from the excited chain to the adjacent chain. Experimental data is collected using tri-axial accelerometers, and is compared to the numerical simulations, finding very good agreement.

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MS12

Large Time-step and Asymptotic-preserving Schemes for Hyperbolic Systems with Sources and their Parabolic Limits

We propose a large time step and asymptotic preserving scheme for the gas dynamics equations with external forces and friction terms. By asymptotic preserving, we mean that the numerical scheme is able to reproduce at the discrete level the parabolic-type asymptotic behaviour satis ed by the continuous equations. By large time-step, we mean that the scheme is stable under a CFL stability condition driven by the (slow) material waves, and not by the (fast) acoustic waves as it is customary in Godunov-type schemes. Nonlinear stability properties are proved and numerical evidences are proposed. A gain of several orders of magnitude in both accuracy and efficiency is showed.

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MS12

Multipathing Problem in Seismic Imaging and a Numerical Solution of Escape Equations

Seismic reflection imaging using the so-called Kirchhoff migration approach involves the task of computing seismic traveltimes between the image point inside a model of the Earth and points on the surface where data are collected. Because of the non-linear nature of traveltime computations, multiple solutions are possible and lead to the multipathing problem. The first-arrival solution is not the most energetic and therefore is not the most desirable for imaging. A possible solution to the multipathing issue is an angle-domain formulation of seismic imaging, which leads to the set of escape equations. Escape equations are decoupled first-order linear equations defined in the extended phase space. I will present a numerical algorithm for an efficient solution of escape equations and its application in seismic imaging.

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MS12

Semiclassical Models for the Schrodinger Equation with Periodic Potentials and Band-crossings

We study the linear Schrodinger equation with a periodic potential in the semiclassical limit. When the so called Bloch band gap is small, the inter-band transition is significant but can not be described by the classical transport model. We derive a quantum classical Liouville system to capture the inter-band transition phenomena. This system can be seen as a first order approximation to the Wigner equation. A classical-quantum hybrid model and the corresponding domain decomposition method are presented to solve this type of system efficiently.

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MS12

High Frequency Approximation in Molecular

Quantum Dynamics

The time dependent Schrödinger equation describing nuclear quantum motion generates high frequency oscillations with respect to time and space. Our results are based on the observation that in the high frequency regime transport equations can either be used for approximating quadratic quantities of the wave function as well as the wave function itself by Gaussian coherent states. The corresponding two families of particle methods are applicable for high dimensional systems.

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MS12

Error Estimates for Gaussian Beam Superpositions

Gaussian beams are asymptotically valid high frequency solutions to hyperbolic partial differential equations, concentrated on a curve through the physical domain. Superpositions of Gaussian beams provide a powerful tool to generate more general high frequency solutions. In contrast to the standard geometrical optics, the Gaussian beam approximation does not break down at caustics. In this talk we discuss numerical methods based on Gaussian beam superpositions and show error estimates in terms of the small wavelength.

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MS13

Solutions to Maxwell-Bloch Equations with Nonvanishing Boundary Conditions

We formulate the inverse scattering transform with nonzero boundary conditions at infinity for (i) the focusing nonlinear Schrodinger equation (ii) the scalar Maxwell-Bloch equations. For both models we derive soliton solutions and discuss their behavior.

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MS13

Light Propagation in Metamaterials with Mixed Positive and Negative Refractive Index

Abstract not available at time of publication.

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MS13

Integrable/Stochastic Polarization Dynamics in Active Media

Resonant interaction of light with a randomly-prepared, lambda-configuration active optical medium 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 and their switching times will be presented .

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MS13

Monte-Carlo Simulations of a Stochastic Maxwell-Bloch System

The resonate interaction of light with an optical media is studied in a Maxwell-Bloch system with two levels, the lower one being degenerate.Using Monte-Carlo simulations, we are able to study the statistics of soliton polarization switching in the randomly prepared material. For simple cases, analytical solutions exist for this stochastic, yet integrable, system.Computations allow further investigation of effects, such as those stemming from non-zero boundary conditions.

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MS13

Inverse-Scattering Transform for the Coupled Coupled Maxwell-Bloch Equations with Inhomogeneous Broadening

This talk will address the solution of the initial value problem for the coupled Maxwell-Bloch equations with inhomogeneous broadening for a three level system, with generic preparation of the medium. The Inverse Scattering Transform for this system was first formulated by Byrne, Gabitov and Kovacic (2003). In this talk we will focus on the (nonlinear) evolution of the scattering data, on the problem of determining the final polarization of the medium, and describing soliton interactions.

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MS14

Coagulation-Fragmentation in Alternative Telomere Length Maintenance

We present a mathematical model of alternative telomere length maintenance based on details of biophysical interactions. The model opens up a couple of interesting mathematical problems such as the validity of a quasi-steady state approximation and dynamic properties of discrete coagulation-fragmentation systems with kernels out of the typically considered classes. We also identify and estimate key factors influencing the length distribution of telomeric circles using numerical simulations for different yeast species.

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MS14

Convergence to Equilibrium for the Coagulation-fragmentation Equations with Detailed Balance and a Finite Critical Mass

We study the speed of convergence to equilibrium of solutions to the coagulation-fragmentation (CF) equations under the assumption of detailed balance. We show that, for a subcritical mass, the linearized equations have a spectral gap in the natural vector space suggested by the entropy. Through estimates of moments of the nonlinear equations, we are able to deduce that subcritical solutions of the CF equations converge to equilibrium exponentially fast whenever uniform-in-time exponential moment bounds are available (such as the Becker-Dring case).

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MS14

On Global Stability for Lifschitz-Sylozov-Wagner Like Systems

This talk is concerned with the stability and asymptotic stability at large time of solutions to a system of equations, which includes the Lifschitz-Slyozov-Wagner (LSW) system in the case when the initial data has compact support. The main result is a proof of weak global asymptotic stability for LSW like systems. Comparison to a quadratic model plays an important part in the proof of the main theorem when the initial data is critical. The quadratic model extends the linear model of Carr and Penrose.

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MS14

On Self-similarity in Coagulation-annihilation Systems

We study the existence of self-similar behaviour in coagulation-annihilation systems with two-species clusters, extending recent work in [Laurençot and van Roessel, J. Phys. A: Math. Theor. 43 (2010) 455210] to systems with more general rate coefficients.

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MS15

Modelling Retinal Waves in Starburst Amacrine Cells

Retinal waves are an example of spontaneous activation in the developing central nervous system. This activity occurs in developing neural circuits prior to visual stimulus. The waves are the result of neighboring retinal cells spiking in a coordinated fashion which spreads across the whole retina. We develop a continuous spatial and temporal model of this phenomenon in order to understand how the wave properties depends on underlying parameters. We use the Fitzhugh-Nagumo model of neuron dynamics and include spatial coupling via a neurotransmitter field representing a novel mechanism for generating spatiotemporal patterns in the developing central nervous system.

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MS15

Spike Metric Analysis of Geometrical Effects in Axonal Computation

Axons are much more than reliable cables in which spikes propagate in a stable manner. Specifically, propagation failures and reflection of pulses were observed experimentally in several neural systems. These unusual computations can be explained in classical nerve equations as a result of the interplay between the ionic currents with geometrical properties of the axon. Such effects can dramatically affect spike trains and consequently, neural coding. We compare trains before and after they are affected by axonal inhomogeneities using a recent spike metric framework.

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MS15

Disrupting Waves of Disease Spread Through a Population: How Interventions Affect the Propagation of Disease Outbreak

Every year, the population of the world faces a number of terrible diseases that spread through populations wreaking havoc on families and world economies. Only one disease has been successfully eradicated: smallpox in 1977. This event was a great triumph for the world and public health, but many more diseases still haunt humanity. The work presented in this talk will be focused on how current campaign tools (routine vaccinations, behavioral changes, and mass vaccination events) affect mathematical models of disease spread through a population. The goal of this research is to understand how to effectively and efficiently disrupt disease propagation.

Joshua Proctor
Intellectual Ventures

MS15

Competing Spatio-temporal Neural Codes Evoked by Inhibition in the Olfactory System

Experiments across different species have shown that perception of odors in the olfactory system is associated with neural encoding patterns. We show that a data-driven computational model reduction for the antennal (olfactory) lobe (AL) of the Manduca sexta moth reveals the nature of experimentally observed persistent spatial and temporal neural encoding patterns and its associated decision-making dynamics. Utilizing the experimental data we reduce a high-dimensional neural network model of the AL to a decision making model. Analyzing the model we conclude that the mechanism responsible for the robust and persistent appearance of neural codes is a stable fixed point. The model is used to explain, predict and direct experiments when odors are mixed or the structure of the network is altered.

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MS16

Emergence of Unsteady Dark Solitary Waves from Large-amplitude Periodic Patterns

DSWs are most well known as exact solutions of the NLS equation. Here it is shown that DSWs can be generated by colliding two periodic patterns. A KdV equation on a periodic background coupled to a phase shift equation is derived. The nonlinearity in the KdV equation is determined by the curvature of the periodic states, and the dispersion is determined by the Krein signature of the periodic state. KdV planforms are also discussed.

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MS16

Weakly Nonlinear Solution of Initial Value Problem for Boussinesq-type Equations

We construct a weakly nonlinear solution of the initial-value problem for a system of coupled regularised Boussinesq equations on the infinite line, in terms of solutions of various Ostrovsky-type equations. The solution for a single Boussinesq equation is given in terms of solutions of the Cauchy problems for two Korteweg-de Vries equations. We also perform relevant numerical simulations to test our formula.

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MS16

Whitham Modulation Equations for Korteweg-de Vries/Kuramoto-Sivashinsky Equations

In this talk, we study the stability of periodic waves for a Korteweg de Vries/Kuramoto Sivaskinsky equation which model a weakly unstable thin film flow down an incline. We will focus on the validity of Whitham's modulation equations that describe large scale perturbations of periodic waves. Of particular interest is the KdV limit where a new Whitham's system is derived which provides new stability criteria.

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MS16

Stability of Homoclinic Orbits of the Nonlinear Schrodinger Equation

We study the linearization of the Nonlinear Schrödinger (NLS) equation about homoclinic orbits of unstable plane wave solutions with two unstable modes. The family of homoclinic orbits as well as a complete set of solutions of the associated linearized NLS equation can be constructed using Bäcklund transformations. We show that iterating Bäcklund transformations saturates instabilities of the seed solution, making the largest dimensional homoclinic orbits the most stable in the sense of linear stability.

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MS16

A Dimension-breaking Phenomenon for Steady Water Waves with Weak Surface Tension

Iooss and Kirchgässner proved that the two-dimensional water wave problem with weak surface tension admits two families of solitary wave solutions of envelope form. The solutions are to leading order described by the nonlinear Schrödinger equation. In this talk I will discuss how these waves generate families of three-dimensional periodically modulated solitary waves in a dimension-breaking bifurcation. The new solutions decay in the direction of propagation and are periodic in the transverse direction. They are related to the Davey-Stewartson equation. The proof is based on a reversible Hamiltonian spatial-dynamics formulation and an infinite-dimensional version of the Lyapunov centre theorem.

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MS17

Nonlinear Optics in Periodic, PT-symmetric Systems

In this talk I will present novel dynamics in nonlinear optical systems with periodic and (P)arity (T)ime symmetric index of refraction. PT symmetry means a complex index of refraction whose real part is an even function and whose imaginary part is odd. we will show how such symmetry adds functionality in recently proposed all optical devices; for example a PT symmetric couplers produce input/output conditions characteristic of an all optical diode.

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MS17

Logarithmic Corrections in Formation of Singularities in 2D Radially Symmetric Reduced Keller-Segel Model

The 2D Keller-Segel model (KS) can be used as a model describing phenomena such as dynamics of bacteria in Petri dish and gravitational collapse of interstellar dust cloud. We study radially symmetric solutions of 2D KS which blows-up in finite time. We simulate a collapsing solution with high accuracy to resolve logarithmic corrections in the temporal dynamics of self-similar scaling length L(t). We combine perturbation approach to the logarithmic corrections with the simulations using a spatially adaptive finite difference method (a variation of adaptive mesh refinement). The numerical method relies on self-similar properties of blowing-up solution.

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MS17

Continuations of NLS Solutions Beyond the Singularity

The nonlinear Schrodinger equation (NLS) is one of the canonical nonlinear equations in physics. In 1965, Kelley showed that the NLS admits solutions that collapse (become singular) at a finite time (distance). Since physical quantities do not become singular, a question which has been open since 1965 is whether and how singular NLS solutions can be continued beyond the singularity. A similar situation occurs in hyperbolic conservation laws, where in the absence of viscosity, the solution can become singular (develop shocks). In that case, there is a huge body of literature on how to continue the inviscid solution beyond the singularity. In contrast, very few studies addressed this question in the NLS. In this talk I will present several potential continuations of the NLS beyond the singularity. These continuations share the universal feature that after the singularity, the solution is only determined up to multiplication by a constant phase term. As a result, the interaction between two post-collapse components (beams) is chaotic, as indeed has been observed recently in experiments with high-power laser beams.

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MS17

A Stochastic Model for Bose-Einstein Condensation

We consider a nonlinear Schrödinger equation with a potential varying randomly in time, which is a model equation in Bose-Einstein condensation or in fiber optics. We study the Cauchy problem in the energy space, establishing random Strichartz estimate. We also give an initial condition for the existence of collapsing state, and discuss the influence of the random potential on a stable standing wave. This is a joint work with Anne de Bouard (Ecole

Polytechnique, France).

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MS17

Waves in Microstructures

Abstract not available at time of publication.

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MS18

Reduced Models of Stratified Internal Waves

Abstract not available at time of publication.

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MS18

Asymptotic Models for Large Amplitude Internal Waves in Weakly Stratified Fluids

We derive nonlinear evolution equations for large amplitude internal waves in weakly stratified fluids. After the linear dispersion relation of the new model is compared with that of the linearized Euler equations, the solitary wave and conjugate state solutions of the model are obtained and compared with other theoretical solutions and field data.

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MS18

Internal Waves in the Ocean Seen from Spectral Perspective

Abstract not available at time of publication.

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MS18

On Stochastic Closures for Finite Amplitude Internal Waves

Recent results concerning the analytic representation of stochastic closures for weakly interacting internal waves at finite amplitude will be presented and contrasted with existing analytic closures in the resonant (infinitesimal amplitude) limit. The two paradigms will be studied using ray tracing techniques that support the analytic results. The ray tracing results further provide a concrete physical interpretation for a transition from a system of coupled oscillators (the resonant limit) to a particle in a potential well (the finite amplitude limit).

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MS19

Hydrodynamic Solitons and Vortices in Polariton Condensates

Exciton-polaritons are composite bosons arising from the strong coupling between quantum well excitons and photons confined in a semiconductor microcavity. They can be easily created by optical excitation, and they can form extended bosonic condensates at relatively high temperatures (10-300 K). Here we will show experiments on the transition from a superfluid phase to shockwaves, vortex and soliton formation when the condensate encounters a potential barrier in its flowpath at different Mach numbers, with specific features arising from the out-of-equilibrium nature of polaritons.

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MS19

Interactions and Asymptotics of Dispersive Shock Waves

The interaction of dispersive shock (DSWs) and rarefaction waves (RWs) associated with the Korteweg–de Vries (KdV) equation are investigated numerically and with Whitham's averaging method; the interaction of DSWs lead to multiphase dynamics. General non-vanishing initial conditions for the KdV equation are considered. KdV is solved for using the inverse scattering transform (IST) method. From IST theory and matched asymptotics, an asymptotic solution for large time is determined and it's found that interacting DSWs eventually form a single DSW.

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MS19

From Superfluid Counterflow to Novel Types of Solitons: Quantum Hydrodynamics with Dilute-gas Bose-Einstein Condensates

Dilute-gas Bose-Einstein condensates provide a versatile tool for the investigation of superfluid hydrodynamics. We experimentally investigate the behavior of a two-component Bose-Einstein Condensate subjected to counterflow between the two components. The counterflow is found to lead to rich dynamics, including a modulational instability, dark-bright soliton trains, and oscillating dark-dark solitons. Our recent and ongoing studies showcase the emergence of intriguing nonlinear behavior in a well controlled model system using ultracold atoms.

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MS19

Dispersive Dam Breaks and Lock Exchanges in a

Two-layer Fluid

Abstract not available at time of publication.

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MS19

Quantum Hydrodynamics and Turbulence in Bose-Einstein Condensates

Quantum turbulence (QT) is comprised of quantized vortices that are definite topological defects arising from the order parameter appearing in Bose-Einstein condensation. Hence QT is expected to yield a simpler model of turbulence than does conventional classical turbulence. A general introduction to this issue and a brief review of the basic concepts are followed by the recent developments in quantum hydrodynamic instability and turbulence in atomic Bose-Einstein condensates.

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MS20

Asymptotics for a Fredholm Determinant Involving the Second Painleve Transcendent

This talk discusses the large s-asymptotics of the determinant $\det(I - \alpha K_s)$ of an integrable Fredholm operator acting on the interval $(-s, s)$ with a real-valued parameter α. The kernel of the operator K_s is constructed out of the Ψ-function associated with the Hastings-McLeod solution of the Painleve II equation. This kernel appears in Random Matrix Theory and describes the critical behavior of the eigenvalue gap probablities of a random Hermitian matrix chosen from the Unitary Ensemble in the bulk double scaling limit near a quadratic zero of the limiting mean eigenvalue density. The given integrable form of the Fredholm operator allows us to connect the resolvent kernel to the solution of a Riemann-Hilbert problem which can be analysed rigorously via the Deift-Zhou nonlinear steepest descent method. We will highlight certain technical features in the implementation of the method related to different choices of the parameter α. This is joint work with Alexander Its.

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MS20

Toeplitz-like Structure of RiemannHilbert Problems

Associated with a (matrix-valued) Riemann–Hilbert problem is a linear singular integral equation involving the Cauchy transform and its left and right limits. By representing this linear equation as an operator on Chebyshev coefficients, we find that it has the structure of a perturbation of a block-Toeplitz operator. In suitably defined spaces, this perturbation is compact. This allows us to prove convergence and stability of a numerical method for solving Riemann–Hilbert problems.

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MS20

On the Elliptic Sine-Gordon Equation

In this talk I will outline the problems that arise when trying to solve this equation in a convex polygon for linearisable boundary conditions. These problem arise from the lack of compatibility of such problems at the corners of the domain, that in turn introduces a lack of integrability in the spectral data. I will outline a strategy for defining an alternative Riemann Hilbert problem whose data are integrable, and discuss the use of this alternative RH problem to solve some linearisable problems explicitly. This is joint work with T Fokas and J Lenells.

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MS20

Automatic Contour Deformation

In many cases the standard contour of a Riemann Hilbert problem is not the most useful one for numerical analysis. For example to calculate the solution of a Riemann Hilbert problem it is often necessary to deform the contour in order to reduce the condition of the problem. Currently these deformations are done by hand and this talk will give some details on how some of these deformations can also be done by an algorithm.

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MS21

Resonant Dynamics of Fourier Modes

We analyze the resonant transfer of energy between Fourier modes for the 1D nonlinear Schrödinger equation in a finite interval with homogeneous Dirichlet or Neumann boundary conditions. For the cubic nonlinearity we show that there is no long term energy exchange between Fourier modes as opposed to higher nonlinearities. This slow dynamics is explained by simple amplitude equations. This method can be applied to other systems to reveal their long term dynamics.

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MS21

Singular Structure of Wave Modes in Rotating Shallow Water

Abstract not available at time of publication.

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MS21

Wave Train Defocusing over a Highly Disordered Bathymetry

Different water wave regimes lead to different types of wave-topography interactions. For example when the bottom topography is considered to be random and rapidly varying, pulse shaped waves are attenuated through this interaction. In some cases the attenuation is asymptotically captured in a linear diffusive-like fashion. In the present work wave trains are considered. Then a multiple scale, amplitude modulation analysis leads to a Nonlinear Schrodinger equation. It is shown that large bottom variations can modify the effective nonlinearity coefficient thus leading to a defocusing effect.

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MS21

Spontaneous Breaking of the Spatial Homogeneity Symmetry in Wave Turbulence and the Emergence of Coherent Structures

Spatial homogeneity, the symmetry property that all statistical moments are functions only of the relative geometry of any configuration of points, can be spontaneously broken by the instability of the finite flux Kolmogorov-Zakharov spectrum in certain (usually one dimensional) situations. As a result, the nature of the statistical attractor changes dramatically, from a sea of resonantly interacting dispersive waves to an ensemble of coherent radiating pulses.

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MS23

Modulational Instability of Weakly Nonlinear Gravity Waves on a Current of Uniform Vorticity in Arbitrary Depth

A nonlinear Schrodinger equation in one dimension is derived from the fully nonlinear water equations in arbitrary depth in the presence of uniform shear current of constant vorticity by using a multiple-scale method. A stability analysis demonstrates that Stokes waves counter propagating over a shear current are generally stable under given conditions of the value of the vorticity for any value of the dispersive parameter kh, where k and h are the carrier wavenumber and depth respectively. The Benjamin-Feir Index (BFI) is a useful parameter to compute the probability of occurrence of rogue waves in a wave field. This index depends on the dispersive and nonlinear coefficients of the NLS equation. We have shown that a shear current co-flowing with the waves increases the value of the BFI and so the number of steep wave events is expected to increase.

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MS23

Numerical and Experimental Investigation for Spectral Evolution of Nonlinear Ocean Surface Waves and their Stability

Efficient and accurate computation of evolving nonlinear ocean surface waves is a challenging hydrodynamic problem. Resolution of various spatial and temporal scales and preservation of required coherent structures, is at heart of an efficient asymptotic model. In this study we examine both short and long term spectral evolution of nonlinear ocean surface waves, in the context of a third-order phase-resolving asymptotic model. An array of randomly initialized Monte-Carlo simulations, solved via Fourier pseudo-spectral method, and corresponding stability analysis of various models in question will be presented. Furthermore, to give further validity to several new findings, a preliminary set of laboratory/wave-tank experiments will also be presented. In particular, the downshifting of the spectral peak and a quasi steady-state of the ensemble averaged spectra, in the absence of damping and wave-breaking have been observed in both the experiments and numerical simulations.

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MS23

Time Dependent Hydro-Elastic Waves

The problem of forced unsteady water waves under an elastic sheet is a model for waves under ice or under large floating structures. Even though small amplitude solitary waves are not predicted to exist by standard perturbation analyses, we find large amplitude solitary waves, and explore their crucial role in the forced problem of a moving load on the surface. This is meant to represent a model of the use of extended ice sheets as roads and aircraft runways.

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MS23

Stability of Traveling Wave Solutions to Euler's Equations

Euler's equations describe the dynamics of gravity waves on the surface of an ideal fluid with arbitrary depth. In this talk, we discuss the stability of periodic traveling wave solutions for the full set of Euler's equations with constant vorticity via a generalization of a non-local formulation of the water wave problem due to Ablowitz, Fokas & Musslimani [Ablowitz *et al* 2006, J. Fluid Mech., Ashton & Fokas 2011, arxiv.org]. We determine the spectral stability for the periodic traveling wave solution by extending Fourier-Floquet analysis to apply to the non-local problem. We will discuss some interesting and new relationships between the stability of the traveling wave with respect to long-wave perturbations and the structure of the bifurcation curve for small amplitude solutions.

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MS23

On the Evolution of Ocean Swell Over Long Distances

Segur et al. (2005) showed mathematically that even weak dissipation can stabilize Benjamin-Feir instability. Their experiments, on deep-water waves in a wave tank, supported this claim for small perturbations; for larger perturbations, they observed frequency downshifting, which is not explained by any current model. This talk summarizes our work to apply these ideas to ocean swell, and to construct an accurate model of downshifting.

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MS24

Four-wave-mixing and Optical Wave Turbulence in Fiber Lasers

An overview of research in optical wave turbulence in fiber lasers will be presented in this talk. Four-wave mixing induced wave turbulence of a number of weakly interacting longitudinal modes generated in nonlinear and dispersive cavity defines basis properties of fiber lasers. Our recent results on coherent structures generation in fiber lasers will be presented.

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MS24

All-optical Control of Polarization State in Optical Fibers for Telecommunication Applications

In this work, we report last developments in all-optical nonlinear control of polarization state in optical fibers based on a counter-propagating four-wave mixing interaction. In particular, we will show that it is possible, using a unique segment of fiber, to all-optically manipulate both the polarization state and intensity profile of telecommunication signals. We will also report significant results dealing with a new pump-free configuration, which give rise to a much easy to implement promising device.

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MS24

Theory of Polarization Attraction in Randomly Birefringent Nonlinear Optical Fibers

We derive the coupled stochastic nonlinear equations describing the interaction among different optical waves in fibers with randomly varying birefringence. These equations describe polarization attraction in conservative lossless polarizers based on cross-polarization modulation, as well as dissipative polarization attraction induced by either stimulated Raman scattering or parametric four-wave mixing. We present extensive numerical simulations that link the stochastic properties of the fiber, such as polarization mode-dispersion, to the repolarization capabilities of the different fiber structures.

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MS24

Hamiltonian Relaxation Phenomena and Applications to Nonlinear Optics

In this talk, we provide a generalized understanding of the phenomenon of polarization attraction. More precisely, we analyze the polarization dynamics of counterpropagating waves in two non standard optical fiber systems, i.e. the spun fiber and the randomly birefringent fiber, the latter being relevant to optical telecommunication systems. Our theoretical analysis is based on recently developed mathematical and geometrical techniques, such as the concept of singular torus. Experimental examples will be also given.

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MS24

Collapses in Optical Turbulence

We consider turbulence in the framework of Nonlinear Schrodinger Equation with focusing nonlinearity, dissipation, and forcing. Dissipation saturates catastrophic growth of collapses, causing their break down into almost linear waves. These waves form a nearly-Gaussian random field which seeds new collapses. We analyze statistics of the amplitude fluctuations in the turbulent filed and connect it to the evolution and structure of individual collapses and the statistics of collapses in the field.

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MS25

On the Dynamics of Turbulence Near a Free Surface

It is becoming increasingly clear that stably-stratified flows can support a stratified turbulence inertial range, different from Kolmogorov's (e.g., Riley and Lindborg, J. Atmos. Sci., 2008). Stratification inhibits vertical motions at larger scales, but the largescale, quasi-horizontal motions produce a strong vertical shearing and small-scale instabilities. The result is a $k^{-5/3}$ horizontal spectrum for the horizontal velocities and density at scales larger than the Ozmidov scale, the largest scale that can overturn. For smaller scales, the classical Kolmogorov $k^{-5/3}$ spectrum applies. Inspired by data taken near the water surface in a tidal river (Chickadel, Talke, Horner-Devine and Jessup, IEEE Geos. Remote Sens. Ltrs., 2011), we explore here to what extent the dynamics of the nonlinear spectral energy transfer of near-surface turbulence with no mean shear (i.e., turbulence bounded by a free-slip surface) is analogous to stablystratified turbulence. To that end we perform DNS of decaying, non-sheared turbulence with $Re_\lambda \sim 100$, but bounded by a free-slip surface. We find that, indeed, the behavior of the flow near the free-slip surface is similar to stratified turbulence, with a tentative $k^{-5/3}$ range. Recent field measurements by Thomson and Polagye (private communication, 2011) and by Dugan and Piotrowski (JGR, 2012) indicate a similar behavior for larger-scale quasi-horizontal flows limited by depth. We propose that the mechanism exhibited by strong stratified flows is a more general feature of turbulent flows in which one component of the velocity has been strongly inhibited.

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James Riley
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MS25

Transient Interfacial Waves - Nonlinear Calculations in Three Dimensions

We investigate nonlinear internal wave generation by tidal flow over realistic topography which is three-dimensional, where few or no calculations exist, particularly for highly nonlinear wave amplitudes. Method is fully dispersive and fully nonlinear. Energy transfer processes in the ocean are investigated as well as propagation in two horizontal directions. Successive Fourier transform is extensively used for rapid calculations.

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MS25

The Effects of Rotation on Internal Solitary Waves

In the weakly nonlinear long wave regime, internal solitary waves are often modeled by the Korteweg-de Vries equation, which is well-known to support an exact solitary wave solution. However, when the effect of background rotation is taken into account, an additional term is needed and the outcome is the Ostrovsky equation. The addition of this term has the drastic effect of destroying the solitary wave solution. Instead an initial solitary-like disturbance decays into radiating oscillatory waves, with the eventual formation of a nonlinear envelope solitary wave, whose carrier wavenumber is determined by an extremum in the group velocity. This process is addressed through a combination of theoretical analyses, numerical simulations and laboratory experiments.

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MS25

How Nonlinear are the Internal Tides in the Luzon Strait?

In recent years, the Luzon Strait has been the focus of extensive field studies, remote observations and numerical simulations to gain more insights on the propagation and generation mechanism(s) of some of the largest internal solitary waves observed worldwide. To complement the previous studies, we performed a laboratory experiment at the Coriolis facility in Grenoble, France, site of the world largest rotating table. We modeled the generation of internal tides using realistic three-dimensional topography, realistic density stratification and barotropic tidal forcing. Particular care was taken to achieve dynamical similarity with the ocean problem. We present here the influence of the tidal characteristics (amplitude, frequency) and of the background rotation on the nonlinear aspects of the internal tide generation.

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MS25

Generation and Propagation of Internal Waves in a Model of the Deep Ocean

We present studies of internal gravity waves in a stratified fluid designed to model the deep ocean. King et al. recently found that stratification in regions of the deep ocean below (previously unknown) turning depths is too weak to support tidally generated internal waves. The present experiments and simulations examine internal wave reflection at turning depths. Further, we study internal wave generation by tidal flow over bottom topography that is below a turning depth.

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MS26

Dispersive Shock Wave Propagation in Weakly Non-Uniform Media

We consider the propagation of dispersive shock waves (DSWs) through weakly non-uniform media in the framework of the KdV equation with a slowly varying dispersion coefficient. We show that the interaction of DSWs with variable environments can result in a number of nonlocal and non-adiabatic responses including the generation of multi-phase regions and expanding soliton trains. In particular, our solutions describe the transformation of shallow-water undular bores on a slope.

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MS26

Dark Solitons, Dispersive Shock Waves and their Transverse Instabilities

Transverse instabilities of dark solitons for the (2+1)-dimensional defocusing nonlinear Schrodinger / Gross-Pitaevskii equation are considered. Asymptotics and computations of the linearized equation yield the dispersion relation, which, in turn, yields the separatrix for the transition between convective and absolute instabilities of dark solitons. The implications for stationary and non-stationary oblique dispersive shock waves are elucidated. Our results have application to controlling nonlinear waves in dispersive media, such as dispersive shocks in Bose-Einstein condensates and nonlinear optics.

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MS26

The Semiclassical Modified Nonlinear Schrdinger Equation

The modified nonlinear Schrödinger (MNLS) equation is a completely integrable system that appears to be a perturbation of the focusing nonlinear Schrödinger (NLS) equation. However, the perturbation is singular and it turns out that one of its effects is that for certain initial data the problem behaves more like a perturbed defocusing NLS equation than a perturbed focusing NLS equation. This effect is particularly dramatic in the semiclassical limit, in which it can be seen that the modulational instability of the unperturbed problem completely disappears in the perturbed problem for certain initial conditions. This is joint work with Jeffery DiFranco and Benson Muite.

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MS26

Thermodynamic Phase Transitions and Shock Singularities

We show that, under rather general assumptions on the form of the entropy function, the energy balance equation for a system in thermodynamic equilibrium is equivalent to a set of nonlinear equations of hydrodynamic type. This set of equations is integrable via the method of characteristics and it provides the equation of state for the gas. The shock wave catastrophe set identifies the phase transition. A family of explicitly solvable models of non-hydrodynamic type such as the classical plasma and the ideal Bose gas is also discussed.

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MS26

Semiclassical Dynamics and Rogue Waves Formation in Quasi 1D Attractive BoseEinstein Condensates: The Riemann-Hilbert Problem Approach

The strongly interacting regime for attractive BoseEinstein condensates (BECs) tightly confined in an extended cylindrical trap is studied. For appropriately prepared, non-collapsing BECs, the ensuing dynamics are found to be governed by the one-dimensional focusing Nonlinear Schrdinger equation (NLS) in the semiclassical (small dispersion) regime. In spite of the modulational instability of this regime, some mathematically rigorous results on the strong asymptotics of the semiclassical limiting solutions were obtained recently. Using these results, implosion-like and explosion-like events are predicted whereby an initial hump focuses into a sharp spike which then explodes into two rapidly oscillating radiative waves (rogue waves), whose initial amplitude is about 3 times the amplitude of the background waves. Seemingly related behavior has been observed in three-dimensional experiments and models, where a BEC with a sufficient number of atoms undergoes collapse. The dynamical regimes we consider, however, are not predicted to undergo collapse. Instead, distinct, ordered structures, appearing after the implosion, yield interesting new observables that may be experimentally accessible. All the dynamical results follow from the rigorous analysis of the Riemann-Hilbert problem that describes the inverse scattering transformation for the NLS.

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MS27

Painlevé Functions and Critical Behavior in Nonlinear Wave Equations

The solution to a nonlinear wave equation associated to a given initial condition will often display two or more qualitatively different behaviors in different regions of space-time, such as having an oscillatory zone and a non-oscillatory zone. The boundaries between these regions may become well-defined in certain limits (such as small dispersion). In this case it is natural to consider the transition behavior between the two regions. In the past three years, it has been discovered that for several equations, including the Korteweg–de Vries, nonlinear Schrödinger, and Camassa–Holm equations, that certain critical behavior can be described for wide classes of initial conditions in terms of Painlevé functions. These functions, which are solutions of nonlinear ordinary differential equations, seem to play a role for nonlinear equations analagous to the role played by the classical special functions for linear equations. We will discuss recent work with P. Miller using the Riemann–Hilbert approach on Painlevé-type asymptotics in solutions of the sine–Gordon equation, which in turn has led to a better understanding of interesting behavior of the Painlevé functions.

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MS27

Large Size Riemann-Hilbert Problems in Random Matrix Theory

We discuss some large size Riemann-Hilbert problems arising from critical phenomena in random matrix theory and non-intersecting Brownian motion models. The size of the Riemann-Hilbert problems is 3x3 or 4x4. The jump contour consists of 10 rays through the origin.

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MS27

Finite-Genus Solutions of Integrable Equations: A Numerical Riemann-Hilbert Approach

For many integrable equations, computing finite-genus solutions can be reduced to computing a certain hyperelliptic Baker-Akhiezer function. We present a Riemann-Hilbert problem, on the plane, for these Baker-Akhiezer functions. After deformation, this Riemann-Hilbert problem is solvable via the numerical method of Sheehan Olver. This gives an efficient and spectrally accurate numerical method for computing finite-genus solutions.

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MS28

Wave Propagation in Anharmonic Discrete Systems

We present some anharmonic nonlinear discrete models and study, numerically and asymptotically, the possibility of propagation of coherent structures. In one of the cases we show the possibility of wave propagation of Toda's solutions type and in another case exponential cusp like traveling wave solution is shown to exist for a cubic interaction. These results are obtained in the fully discrete regime.

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MS28

Stable, Conservative Solution Methods for Large, Stiff Hamiltonian Systems Modeling Coherent Phenomena in Nonlinear Optics and Biophysics

A variety of problems in biophysics and nonlinear optics lead to the need to solve large, stiff, mildly nonlinear systems of ODEs that have Hamiltonian form, or perturbations of such by slight dissipation or noise. This talk presents a variant of the discrete gradient approach of Gonzales and Simo, adapted to deal with stiffness in the common scenario where this arises only from dominant linear terms, not the nonlinearities. Several applications will be considered as time permits; in particular, some new coherent phenomena in ODE systems of discrete nonlinear Schrödinger equation form relating to a novel continuum limit approximation, quite different from the usual NLS approximation.

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MS28

Second Harmonic Generation in Negative Index Materials

We present novel energy conversion from the fundamental frequency to the second harmonic by use of negative index materials. One of the most fundamental properties of negative index materials is an opposite directionality of the Poynting vector, thus energy transfer occurs while the fields counterpropagate, instead of the traditional copropagating format. By clever use of conservation laws we can find input output solutions and show efficient energy conversion even in the presence of phase mismacth

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MS28
Instabilities of Breathers in a Discrete Nls

We review some numerical and analytical results on the continuation of breathers in the cubic discrete NLS equation in finite one dimensional lattices. Breathers can be viewed as fixed points in a reduced system and we use the stability properties of breathers to obtain information on the topology of the energy hypersurface in a system of three sites. The change to a connected energy hypersurface corresponds to elliptic-hyperbolic breathers, and we study numerically Lyapunov periodic orbits, and their stable and unstable manifolds. We see evidence of homoclinic orbits and we also discuss heteroclinic orbits and the question of transport of energy.

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MS28
Light Propagation in Two Dimensional Plasmonic Arrays

We present results on the dynamics of light beams propagating in two dimensional waveguides. We show how different configurations provide a rich dynamics of localization, solitary wave formation and stability.

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MS29
From Newton's Cradle to the p-Schrödinger Equation

We study localized waves in chains of oscillators coupled by Hertzian interactions, a problem originally motivated by the Newton's cradle under the effect of gravity. We consider an unusual setting where local oscillations and binary collisions occur on similar time scales. Using both direct numerical computations and an asymptotic model (the discrete p-Schrödinger equation), we obtain static and traveling breathers with unusual properties, including enhanced localization, almost vanishing Peierls-Nabarro barrier and direction-reversing motion.

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MS29
Nonlinear Frequency Conversion Through Driven Granular Media

The frequency spectrum of vibrational based sources is important in a variety of applications. We examine methods to control the spectra of these sources through driven granular crystals. The nonlinear Hertzian interaction allows granular systems to be highly tunable and exhibit three distinct regimes, linear, weakly nonlinear, and strongly nonlinear. By varying the precompression and length of the granular chain, we leverage nonlinear phenomena to shift energy between modes of different frequencies.

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MS29
Dispersion Estimation for Weakly and Strongly Nonlinear Periodic Systems

Techniques developed for the estimation of the dispersion properties of nonlinear periodic media are presented. Weekly nonlinear systems are first analyzed through a perturbation approach implemented in a commercial FE tool. Next, strongly nonlinear one-dimensional and two-dimensional granular lattices are studied as examples of strongly nonlinear systems through a harmonic balance method. Both methodologies illustrate the amplitude-dependent dispersion properties of nonlinear systems, and suggest their potentials as tunable waveguides.

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MS29
Resonances, Solitary Waves, and Passive Wave Redirection in Granular Media

We discuss rich dynamics of ordered heterogeneous granular media with no precompression, including countable infinities of nonlinear resonances in dimer chains leading to strong attenuation of propagating pulses; countable infinities of nonlinear anti-resonances in the same dimers leading to families of solitary waves; and capacity for passive wave redirection in weakly coupled homogeneous chains through Landau-Zenner tunneling in space. The nonlinear dynamical mechanisms governing these phenomena are studied leading to fully predictive material designs.

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MS30

Variational Methods for Solitary Water Waves

I will speak on variational methods for solitary waves on the free surface of a two-dimensional steady, irrotational flow of water, acted upon by gravity. I will begin by formulating the steady water wave problem as a nonlinear pseudodifferential equation via conformal mappings and compare to Babenko's equation for Stokes waves. I will argue non-existence in the infinite-depth case by Pohozaev identity techniques. After commenting how the Korteweg-de Vries equation arises in the finite-depth case as the leading-order approximation in a certain weakly-nonlinear long-wave regime, I will explain existence in the finite-depth case of solitary waves as minimizers.

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MS30

Small Divisors Made Visible

Wavefront propagation in a multiply periodic medium exposes in a very tangible way the small divisor problem of classical mechanics. Consider the speed of a macroscopically planar wavefront as a function of direction angle in R^2 . Naive perturbation analysis in the limit of small variations from a uniform medium leads to a formal asymptotic expansion, whose terms are in one-to-one correspondence with rational di- rections: A line from the origin has a rational direction if it intersects a prime integer lattice point $\mathbf{k}_* = \mathbf{m}_*, \mathbf{n}_*)$, where m_* and n_* are integers with no common factor. The sum diverges in any rational direction, but standard diophantine analysis establishes convergence in almost all of the remaining irrational directions. Obviously the small divisor series begs the question what is the actual structure of the speed function? Formal singular perturbation analysis provides an intriguing clue: Let e be the gauge parameter measuring the deviation from a uniform medium: The partial sum of the small divisor series with $|k_*| < \epsilon^{-p}$, (p = positive exponent) is regarded as an outer expansion and we examine its asymptotic matching to inner expansions around all the rational directions with $|k_*| < \epsilon^{-p}$. The inner expansions are done by Arnold averaging. We use a nonstandard variation of the usual Diophantine analysis to show that the outer expansion matches with all the inner expansions if $0 < p < 16$. The conjecture that the uniformly valid expansion based upon this matched asymptotics approximates the real speed function as $\epsilon \to 0$ will be tested by a numerical solution by J. Wilkening.

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MS30

Traveling Water Waves in Three Dimensions

In this talk I shall present a new single equation for the surface elevation of a traveling water-wave in an incompressible, inviscid, irrotational fluid. This new equation is derived from the full set of Eulers Equations and is valid for both a one- and two- dimensional traveling wave surfaces, with and without surface tension. Some sample solutions, obtained through Stokes expansions as well as numerical computations, will also be presented.

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MS30

Global Continuation for Solitary Waves with Vorticity

We consider the solitary water wave problem with an arbitrary distribution of vorticity. Small amplitude solutions have been constructed in [Hur, 2008] and later in [Groves and Wahlén, 2008]. We use degree theory to prove a continuation result, constructing a global connected set of solutions.

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MS30

Breakdown of Self-similarity at the Crests of Large-amplitude Standing Water Waves

We study the limiting behavior of large-amplitude standing waves on deep water using high-resolution numerical simulations in double and quadruple precision. While traveling waves are known to approach Stokes's 120 degree corner wave in an asymptotically self-similar manner, standing waves do not approach Penney and Price's conjectured 90 degree corner solution. Instead, a variety of oscillatory structures form near the crest tip, causing the bifurcation curve to fragment into disjoint branches. Additional branches of solutions nucleate and merge as fluid depth decreases. For comparison, we consider the effect of small divisors in a model KAM system.

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MS31

Applications of Carrier-Envelope Phase-Locked Lasers

Frequency combs broadband phase-coherent optical sources are finding an increasing number of new applications in the field of metrology.

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MS31
Ultralow Noise Mode-locked Semiconductor Diode Based Fiber Lasers

The development of ultrastable mode-locked lasers based on harmonic mode-locking have recently produced wide spaced frequency combs (∼10 GHz) with long term stability and narrow comb tooth linewidth (∼500 Hz). The overall phase noise (timing jitter) integrated to Nyquist can be less that 2 femtoseconds. Key to achieving this level of performance requires a fundamental understanding of the underlying nonlinear optical mechanisms of pulse generation, as well as the environmental effect that drive can perturb the systems overall stability. This talk will review the recent progress in stabilized combs from harmonically mode-locked diode lasers and highlight key mechanisms that play critical roles in the overall output pulse train characteristics.

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MS31
Coherent Combs: Optimized Supercontinuum Generation for Carrier-envelope Phase-locked Lasers

The optical frequency comb has become an indispensable tool in many areas of pure and applied science, opening new frontiers in fields as diverse as astrophysics, atomic physics and sensing. However, the generation of broadband phase-stable combs for the most demanding applications still often remains a matter of trial and error, limiting the potential uptake of this technology. The use of optical fiber supercontinuum generation for comb stabilization is of course a well-known technique, but surprisingly, the dynamics of this process and the impact on comb stability remain poorly understood. In this talk we review work in this field, with the overall aim of providing clear guidelines for the generation of stable phase-stabilised frequency combs from mode-locked lasers. If time permits, links with other areas of wave instability physics will also be addressed.

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MS31
Chip-Based Parametric Frequency Combs

We describe recent work on the generation of ultrabroadband frequency combs based on parametric four-wave mixing in silicon-based micro resonators. This system exhibits extreme nonlinear optical effects at modest power levels, and many issues related to the dynamics, noise, and mode locking remain not well understood. Ultimately, this system offer the promise of highly compact, robust sources for metrology, spectroscopy, and ultrafast applications.

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MS31
Carrier-envelope Phase Locking of Multi-pulse Lasers

We propose the use of an intra-cavity Mach Zehnder interferometer (MZI), for increasing the repetition rate at which carrier-envelope phase-locked pulses are generated in passively mode-locked fiber lasers. The attractive feature of the proposed scheme is that light escaping through the open output ports of the MZI can be used as a monitor signal feeding a servo loop that allows multiple pulses to co-exist in the cavity, while rigidly controlling their separation. The proposed scheme enables in principle a significant increase in the pulse-rate with no deterioration in the properties of the generated pulses.

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MS32
Shock-driven Jamming and Periodic Fracture at Particulate Interfaces

When a monolayer of hydrophobic particles at the air-water interface is disturbed by a surfactant droplet, a radially divergent surfactant shock emanates and packs the particles into a jammed annulus that grows with time. This 2D, disordered, elastic solid then fractures to form periodic triangular cracks with robust geometrical features. We describe a simple experiment complemented by minimal simulation that studies the formation and failure of a disordered solid at the air-water interface.

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MS32
Localized Structures in Complex Fluids

In the Faraday system a thin layer of fluid is vertically vibrated. The primary instability is a transition from a flat to a wavy interface. While much is known about extended states in this system, far less is known about localized structures. Recently, a new class of localized structures kinks and persistent holes were discovered in the Faraday system with particulate suspensions as the working fluid. These structures are markedly different from other examples: they oscillate about an unstable state and are inaccessible via infinitesimal perturbation from the weakly nonlinear states. I will present experimental results on these structures in particulate suspensions, worm-like micellar solutions, and emulsions.

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MS32

Plants in Motion: Mechanics and Function in Winding Tendrils

The helical coiling of plant tendrils has fascinated scientists for centuries, yet the mechanism of coiling remains elusive. Moreover, despite Darwin's widely accepted interpretation of coiled tendrils as soft springs, their mechanical behavior is unknown. Our experiments on cucumber tendrils demonstrate that tendril coiling occurs via asymmetric contraction of an internal 'fiber ribbon' of specialized cells. The mechanical behavior of tendrils under tension adds a new twist to the story and quantifies Darwins original interpretation.

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MS32

Helical Swimming in Viscoelastic Fluids

Many bacteria swim by rotating helical flagella. These cells often live in polymer suspensions, which are viscoelastic. To explore the effect of viscoelasticity on the bacterial motility, the helical swimmer is simulated by a model system - a rotating helical coil. When immersed in a viscoelastic fluid, the helix swims faster as compared with the Newtonian case. The enhancement is maximized when the rotation rate of the helix matches the relaxation time of the fluid.

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MS32

Linking Structure to Dynamics in Weak Turbulence

Despite an enormous range of applications and centuries of scientific study, understanding and predicting the flow of fluids remains a tremendous challenge, particularly when the flow is chaotic or turbulent. Turbulent flows tend to be characterized by violent fluctuations, broad ranges of strongly coupled degrees of freedom, and significant variability in space and time. But despite all this, turbulent is not random. Rather, it tends to self-organize into striking patterns and features. Some of these "coherent structures,' such as strong vortices, are readily apparent; others are more subtle. But how much can we learn about the flow from studying coherent structures? To begin to answer this question, I will discuss experiments that suggest deep links between flow structure (that is, localized spatiotemporally coherent regions) and dynamics (that is, the flow of energy in the system).

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MS33

A Numerical Study of Stability of Periodic Kuramoto-Sivashinsky Waves

We consider the spectral and nonlinear stability of periodic traveling wave solutions of a generalized Kuramoto-Sivashinsky equation. In particular, we resolve the long-standing question of nonlinear modulational stability by demonstrating that spectrally stable waves are nonlinearly stable when subject to small localized (integrable) perturbations. We carry out a numerical Evans function study of the spectral problem and find bands of spectrally stable periodic travelling waves, in close agreement with previous numerical studies of Frisch-She-Thual, Bar-Nepomnyashchy, Chang-Demekhin-Kopelevich, and others carried out by other techniques. We also compare predictions of the associated Whitham modulation equations, which formally describe the dynamics of weak large scale perturbations of a periodic wavetrain, with numerical time evolution studies, demonstrating their effectiveness at a practical level.

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MS33

Stability of Periodic Traveling Waves in a KdV/Kuramoto-Sivashinsky Equation Equation

In this talk, we consider the spectral and nonlinear stability of periodic traveling wave solutions of a KdV/Kuramoto-Sivashinsky equation modeling thin film flow down an incline. In special cases it has been known since 1976 that, when subject to small localized perturbations, spectrally stable solutions of this form exist. Although numerical time-evolution studies indicate that these waves should also be nonlinearly stable to such perturbations, an analytical verification of this result has only recently been provided. Here, I will discuss this recent result and, time permitting, I will discuss numerical and analytical verifications of the required spectral stability and structural hypothesis of this theorem in particular canonical limits of dispersion/dissipation. This is joint work with Blake Barker, Pascal Noble, L. Miguel Rodrigues, and Kevin Zumbrun.

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MS33

(In)stability of Traveling Waves for the Sine-Gordon Equation: How Bands Balloon

Traveling waves of the Sine-Gordon equation exist as kinks and oscillations in both the subluminal and superluminal regimes. It has been folklore that only subluminal kinks are stable in the spectral sense and all of the other waves are unstable. The spectral problem has, however, not been properly analyzed because of its non self-adjoint structure. We show that spectral bands can become balloons, and do so except in the subluminal kink case, which is indeed stable.

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MS33

On the Spectral Stability of Nonlinear Waves in Continuum Mechanics

We discuss some non-standard spectral problems associated to the stability of nonlinear waves in continuum mechanics. Applications to elasto-chemical waves and waves in thermoelasticity, among others, will be discussed.

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MS33

Breather Stability in Klein-Gordon Equations

We will present results on breather stability in Klein-Gordon equations. We will show results for discrete Klein-Gordon chains that relate the type of multibreathers – where oscillators are at rest, in or out of phase – to the sign of eigenvalues in the perturbation matrix. The weak coupling perturbation is with respect to the case without coupling between the oscillators. Next, we will show results for continuous Klein-Gordon equations that approximate the discrete ones.

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MS34

Localized Oscillations in a Nonvariational Swift - Hohenberg Equation

Stationary spatially localized states occur in many systems of physical interest, and are often organized in a so-called 'snakes-and- ladders' structure. In recent years the Swift-Hohenberg equation has garnered much attention as the standard model exhibiting this behavior. In this talk I consider a generalized version of the Swift- Hohenberg equation and show that it exhibits, in addition to the usual stationary localized states, both oscillating localized states and traveling pulses.

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MS34

Interacting Invasion Fronts

We consider invasion fronts in systems of reaction-diffusion equations representing the displacement of an unstable homogeneous state by a stable one. In particular, we are interested in systems for which this transition takes place via a third, intermediate state. In some cases, the invasion process splits into a pair of propagating fronts traveling with different speeds while in other situations a single front is formed. We discuss mechanisms leading to both behaviors and consider applications to pattern forming systems using amplitude equations.

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MS34

Colliding Convectons

Convectons are strongly nonlinear spatially localized states found in thermally driven fluid systems. In binary fluid convection with midplane reflection symmetry convectons of odd and even parity lie on a pair of intertwined branches (J. Fluid Mech. 667 (2011) 586) that form the backbone of the snakes-and-ladders structure of the so-called pinning region. These branches are connected by branches of asymmetric localized states that drift. When the midplane reflection symmetry is broken, the odd parity convectons also drift, greatly modifying the snakes-and-ladders structure of the pinning region. The resulting speed depends on the magnitude of the symmetry-breaking and the convecton length. Head-on and follow-on collisions between odd parity drifting convectons of different lengths are described and the results compared with corresponding dynamics in a Swift-Hohenberg model studied by Houghton and Knobloch (PRE 84 (2011) 016204).

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MS34

Gluing Localized Structures in Reaction-diffusion

Systems

The Swift–Hohenberg equation serves as a model system to study pattern formation in reaction-diffusion equations. An infinite family of stationary multi-pulse spot solutions to the radially symmetric Swift–Hohenberg equation are constructed for dimensions one through three. This requires matching a spot and ring solution, which both scale identically with the bifurcation parameter. The multi-pulses exhibit an anomalous scaling that differs from those for each of the glued solutions.

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MS34

Heterogeneity-induced Spot Dynamics in Dissipative Systems

We discuss the behaviors of traveling 2D spots arising in a three component reaction diffusion system when the media has a jump heterogeneity along the line. The traveling spot responds in various ways depending on the the height of the jump and the incident angle when it encounters the jump line. Refraction and reflection are commonly observed. Two issues are discussed here: One is the relation between the incident angle and the refraction angle when the spot crosses the jump. In a scaling limit near a drift bifurcation, a Snell's-like law holds for the refraction case. The other is the transition from refraction to reflection. Such a transition occurs as the incident angle is increased for a fixed height or the height is increased for a fixed incident angle. As the angle (or height) approaches the critical one, the spot spends much longer time in the right half plane after crossing the jump line and it eventually converges to the one traveling parallel to the jump line but infinitely far from it, namely it is a traveling spot in the homogeneous space located at right infinity. We call such a special solution "scattor" located at infinity.

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MS35

Symbolic Computation of Point Symmetries of an Infinite Family of Multi-point Correlation Equationsin Turbulence Theory

The nonlinear Euler or Navier-Stokes equations governing the incompressible fluid motions can be re-cast through ensemble averaging into an infinite countable system of multi-point correlation equations for the unknown correlation tensors of increasing order. In particular, the first such tensor is the mean flow velocity. The system consists of coupled linear partial differential equations of increasing complexity. We demonstrate the use of a modification of GeM symbolic software for Maple to consistently seek symmetries of such a system of equations, in particular, to discover symmetries of multi-point correlation equations inherited from the original nonlinear model. This is a joint work with Andreas Rosteck and Martin Oberlack from TU Darmstadt.

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MS35

Symbolic Computation of Perturbation-Iteration Solutions for Nonlinear Differential Equations

An
algorithm for the symbolic computation of perturbation-iteration solutions of nonlinear differential equations will be presented. In the algorithm, the number of correction terms in the perturbation expansion and the number of terms in the Taylor expansion can be arbitrary. The steps of the algorithm will be illustrated on a Bratu type initial value problem. The algorithm has been implemented in Mathematica. The package PerturbationIteration.m will be discussed and demonstrated.

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MS35

Symbolic Computation of Scaling Invariant Lax Pairs in Operator Form for Integrable Systems

Based on scaling symmetry properties, a direct method to compute Lax pairs in operator form for completely integrable systems will be presented. By splitting the determining equations for the Lax pair into kinematic and dynamical constraints, the problem can be reduced to solving nonlinear algebraic equations. The method will be illustrated with well-known examples from soliton theory and applied to a three-parameter class of fifth-order KdV-like evolution equations. A Mathematica implementation will be demonstrated.

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MS35

Construction of Lax Pairs in Matrix Form and the Drinfel'd-Sokolov Method for Conservation Laws

We will present an algorithmic method for the construction of a class of Lax pairs in matrix form for completely integrable nonlinear PDEs. Using a method by Drinfel'd and Sokolov, the Lax pairs allow one to construct conservation laws for the given PDE. The method can be implemented in any computer algebra system. Prototype Mathematica software will be demonstrated for nonlinear integrable evolution equations, including the Korteweg-de Vries, sine-Gordon, and nonlinear Schrodinger equations.

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MS35

Traveling Waves and Conservation Laws for Complex mKdV-type Equations

Traveling waves and conservation laws are presented for a class of U(1)-invariant complex mKdV equations containing the known integrable generalizations of the real mKdV equation. We derive new complex solitary waves and kinks that generalize the well-known mKdV sech and tanh solutions. With respect to conservation laws, we explicitly find all first-order conserved densities that yield phase-invariant counterparts of the mKdV conserved densities for momentum, energy, and Galilean energy, and a new conserved density describing the angular twist of complex kink solutions.

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MS36

The Brownian Rachet Revisited: Multiple Filamentous Bundle Growth

We present a model based on a diffusion formalism for the Brownian Rachet (BR), which we extend to incorporate a bundle of N identical filaments. In the absence of a load, the bundle growth rate is similar to that of a single filament. However, under the stalling condition, the bundle can oppose N times the external force. We derive a set of relationships describing the velocity of the BR movement (V_z) and its apparent diffusivity (D_z) as functions of the resistant force (F) and the number of filaments in a bundle (N).

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MS36

Vegetative Pattern Formation Model Systems: Comparison of Turing Diffusive and Differential Flow Instabilities

A particular interaction-diffusion plant-surface water model system for the development of spontaneous stationary vegetative patterns in an arid flat environment is investigated by means of a weakly nonlinear diffusive instability analysis. The main results of this analysis can be represented by closed-form plots in the rate of precipitation versus the specific rate of plant loss parameter space. From these plots, regions corresponding to bare ground and vegetative patterns consisting of tiger bush, labyrinth-like mazes, pearled bush, irregular mosaics, and homogeneous distributions of vegetation may be identified in this parameter space. Then those Turing diffusive instability predictions are compared with both relevant observational evidence and existing numerical simulations involving differential flow migrating stripe instabilities for the associated interaction-dispersion-advection plant-surface water model system.

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MS36

The Stability of Hot-Spots in a Reaction-Diffusion Model of Urban Crime

Over the past five years, agent-based stochastic models have been developed by various researchers to predict spatio-temporal concentrations of criminal activity in urban settings. The continuum of these models leads to reaction-diffusion systems with chemotactic terms, that have some common features with more well-known prey-taxis type of predator-prey interactions. In this cotext, and in a particular singularly perturbed limit, we analytically construct localized equilibrium and quasi-equilibrium solutions characterizing hot-spots of criminal activity for the reaction-diffusion system of Short et al. (Mathematical Models and Methods in Applied Science, Vol. 18, Suppl. 2008, pp. 1249-1267). Explicit thresholds for the diffusivity of the criminal activity density determining the stability of these localized patterns are obtained for 1-D and 2-D domains by first deriving and then analyzing a novel class of nonlocal eigenvalue problems (NLEP). The implications of these results are discussed together with some open problems related to the dynamics of hot-spot patterns.

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MS36

Mussel Pattern Formation Model Systems: Comparison of Turing Diffusive and Differential Flow Instabilities

A particular interaction-diffusion mussel-algae model system for the development of spontaneous stationary young mussel bed patterning on a homogeneous substrate covered by a static marine layer containing algae as a food source is investigated employing a weakly nonlinear diffusive instability analysis. The main results of this analysis can be represented by plots in the ratio of mussel motility to algae lateral diffusion versus the rate of mussel growth parameter space. From these plots, regions corresponding to bare sediment and mussel patterns consisting of bands, labyrinth-like mazes, hexagonal arrays of clumps or gaps, irregular mosaics, and homogeneous distributions of low to high density may be identified in this parameter space. Then those Turing diffusive instabiltiy predictions are compared with both relevant laboratory experimental evidence and existing numerical simulations involving differential flow migrating band instabilities for the associated interaction-dispersion-advection mussel-algae model system.

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MS36

Row Formation in Lepidopteran Wings by Origin-Dependent Cell Adhesion: An Individual Cell Interaction Model

Regardless of the obvious differences in the color patterns exhibited by lepidopteran wings in nature, the scale cells that display colors have a remarkable similarity in spatial patterning. Precursors of scale cells develop and migrate into rows roughly parallel to the proximodistal axis. Experiments have revealed that a gradient of activity along the wings, as well as the maintenance of cell adhesivity within each cell, may have been reasons for the formation of rows. In addition, cell polarization along the proximodistal axis in some species, and the extension of filopodia in response to protein expression, are observed. Based on mechanisms observed in experiments, a model of individual precursor interaction and migration is developed to simulate the formation of parallel rows. The results show that the origin dependent cell adhesion is crucial in producing parallel rows, although short-range and long-range cell interactions are important in generating stable spatial patterns. In contrast, the effect of polarization is less significant. This individual cell interaction model is compared with the existing nonlinear differential integral origin-dependent cell adhesion model using cell density as a model variable.

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MS37

Wilton Ripples in Weakly Nonlinear Models

A method for computing Wilton ripples, traveling waves supported at two resonant harmonics, is presented for a class of weakly nonlinear model equations. This method is perturbative in nature; all perturbation orders are computed exactly. The method is used to numerically compute solution profiles as well as the disc of analyticity of branches of solutions. The procedure provides a natural framework to prove existence and analyticity of branches of solutions.

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MS37

Time-periodic Vortex Sheets with Surface Tension

We present results from joint work with Jon Wilkening on computation of time-periodic solutions of the vortex sheet with surface tension. These are found by defining a functional which is zero for time-periodic solutions and positive otherwise; the functional is then minimized by a gradient descent algorithm. Differences between solutions with zero and nonzero mean vortex sheet strength will be discussed. If time allows, a discussion of analytical progress on the question of existence of these solutions (which is joint work with C. Eugene Wayne) will be included.

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MS37

On the Existence and Stability of Solitary-wave Solutions to a Class of Evolution Equations of Whitham Type

We consider a class of pseudodifferential evolution equations of the form

$$u_t + (n(u) + Lu)_x = 0,$$

in which L is a linear smoothing operator and n is at least quadratic near the origin; this class includes in particular the Whitham equation. A family of solitary-wave solutions is found using a constrained minimisation principle and concentration-compactness methods for noncoercive functionals. The solitary waves are approximated by (scalings of) the corresponding solutions to partial differential equations arising as weakly nonlinear approximations; in the case of the Whitham equation the approximation is the Korteweg-deVries equation. We also demonstrate that the family of solitary-wave solutions is conditionally energetically stable.

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MS37

Stability of Gravity Waves with Surface Tension

Recently, a reformulation of the surface water wave problem was presented, allowing improved computational efficiency [Ablowitz *et al* 2006, J. Fluid Mech.]. Building on previous work [Akers & Nicholls 2010, SIAM J. Appl. Math., Deconinck & Oliveras 2011, J. Fluid Mech.], we compute stationary periodic solutions of the problem, in the presence of small surface tension. The aim of the project is to examine the perturbative effect of surface tension on the slow-growing oscillatory instabilities in water waves.

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MS38

Dependence of Mode-locked Laser Linewidth on Pulse Parameter Jitter

We study the spectral linewidth of a finite sequence of near-identical pulses produced by a model for mode-locked lasers. In particular, we show how dispersive radiation can have a significant impact on the random dynamics of the pulse phases, translating to an increased linewidth relative to studies neglecting this phenomenon. Using simulations, we compare the true probability of critical line broadening with the approximate value obtained by using the computed variance with a Gaussian assumption.

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MS38

Effect of the Birefringent Beat Length on Variability in Passively Modelocked Fiber Lasers

Birefringence leads to sensitivity of the power transfer to polarization controller settings, loop length, and birefringent beat length in passively modelocked fiber lasers that use nonlinear polarization rotation for fast saturable absorption. We discuss the parameters that lead to the greatest sensitivity and suggest good operating regimes for these lasers.

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MS38

Engineering the Laser Cavity Transmission for Enhanced Energy in Mode-locked Fiber Lasers

The multi-pulsing instability of mode-locked fiber lasers must be avoided in applications where high energy pulses are required. Recently by using a simple geometric model, we showed that it is possible to engineer the laser cavity dynamics by modifying the nonlinear loss curve. In this paper, we theoretically demonstrated that the energy performance can be increased by including a second set of waveplates and polarizer to a laser cavity mode-locked by a set of waveplates and polarizer.

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MS38

Linearized Stability Analysis of the Haus Mode-Locking Equation

Haus mode-locking equation (HME) is the simplest scalar model for mode-locking, in which the fast saturable absorber is modeled as a loss term proportional to the intensity of the electrical field. There are several models introduced for the fast saturable absorption that claimed would be a better match to the physical saturable absorption process. We perform a parameter study of the HME with these different saturable absorption models.

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MS39

Swimming and Propulsion in Complex Fluids

Abstract not available at time of publication.

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MS39

Microbial Flow Fields, Noise, and Cell-cell Interactions

It is currently believed that deterministic long-range fluid dynamical effects govern bacterial cell-cell and cell-surface scattering - the elementary events that lead to swarming and collective swimming in active suspensions and to the formation of biofilms. I will present direct measurements of the bacterial flow field, generated by individual swimming Escherichia coli, and use these measurements to show that rotational diffusion drowns out long-range hydrodynamic effects in cell-cell and cell-surface interactions.

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MS39

Title Not Available at Time of Publication

Abstract not available at time of publication.

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MS39

Fluidic Computation: Dynamics of Drops and Bubbles in Geometrical Fluid Networks

Abstract not available at time of publication.

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MS39

Dynamics of Passive Flexible Wings

We investigate the dynamics of passive flexible wings freely falling under the influence of gravity. Particular attention is given to elucidating the role of flexibility in passive flight. The effect of bending on the dynamics of fluttering wings is examined through an experimental investigation of deformable rectangular wings falling in water. Elastic deformations induced by the flow strongly affect the flight characteristics and suggest the existence of an optimal bending rigidity minimizing the descent velocity.

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MS40

Two Parameter Methods for Symmetrizable Non-self-adjoint Eigenproblems

Many apparently non-self-adjoint eigenproblems can be recast in the form $Ay - \lambda By = 0$ where A and B are self-adjoint operators in a suitable Hilbert space. They may however be indefinite, and the use of a two parameter embedding $Ay - \lambda By = \mu y$ will be explored. Under fairly general conditions this allows one to "see" certain aspects of the spectrum in terms of the (λ, μ) eigencurves.

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MS40

Index Theorems for Quadratic Pencils with Applications

In dispersive wave equations which are second-order in time, e.g., sine-Gordon and the "good" Boussinesq, the linearized eigenvalue problem associated with the spectral stability of a wave can be realized as a quadratic pencil, where each coefficient of the pencil is either a self-adjoint or skew-symmetric operator. There is a well-developed unstable eigenvalue index theory for linear pencils (going back to Grillakis, Jones, etc., and continuing to Pelinovsky, K/Kevrekidis/Sandstede, etc.), which arise when discussing generalized KdV, coupled systems of Schrödinger equations, etc.; however, the theory is not as well established for quadratic pencils. In this talk I will discuss the extension of the linear theory to the quadratic theory, and apply the theoretical results to the study of the spectral stability of spatially periodic waves.

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MS40

Evans-Krein Function and Eigenvalue Counts

The key question in spectral stability of nonlinear waves is the existence of eigenvalues with positive real part of a linearized operator. Two concepts very different in nature proved to be useful in search for such an unstable spectrum: the Evans function, an analytic function with zeros at isolated unstable eigenvalues, and the Krein signature, an algebraic quantity capturing the ability of an eigenvalue to be or to become unstable under a change of a parameter in a system. Although the Evans function does not provide full information about the Krein signature, we show that its simple extension, the Evans-Krein function, allows to calculate the Krein signature of an eigenvalue at almost no additional computational cost. The method used also enables us to give very elegant proofs of eigenvalue counts for linearized Hamiltonians: the Grillakis-Shatah-Strauss criterion, its generalization for systems with broken Hamiltonian symmetry, and a count of real eigenvalues for diagonazible Hamiltonians originally obtained by Jones.

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MS40

Stability of Solitary Waves of a Sixth-Order Boussinesq Equation

We consider the stability of solitary waves of a sixth-order Boussinesq equation. For a class of homogeneous nonlinearities, we determine the nodal set of the function $d''(c)$ that determines the stability of solitary waves.

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MS40

Spectral Pollution and Boundary Conditions for PDEs on Singular Domains

PDE spectral problems on singular domains (waveguides; exterior domains; domains in which coefficients blow up or strong ellipticity fails) often have essential spectra. As a consequence, variational methods and domain truncation methods may suffer from spectral pollution: eigenvalues are generated which converge to points not in the spectrum of the original problem. This talk will review some approaches for avoiding this undesirable phenomenon, including an approach proposed by the author involving the use of relatively compact dissipative perturbations.

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MS41
Patterns on Sea Urchin Embryos

Patterns of bone morphogen proteins (BMP) on embryos are important for development. BMP patterns have been studied extensively on fly (drosophila melanogaster) embryos. This joint project was motivated by experimental work of Prof. C. Bradham on sea urchin embryos. We endeavor to explain a number of experimental observations using ARD modeling, and we are in the process of conducting new epxeriments suggested by the analysis.

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MS41
Poiseuille Flow and Apparent Viscosity of Nematic Liquid-crystals

Abstract not available at time of publication.

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MS41
Fundamental Chemotactic Traveling Wave Phenomena

Advection-Reaction-Diffusion systems are commonplace in the mathematical biology literature on pattern formation and structure in cell populations. Where directed cell motion in response to a biochemical gradient occurs - a process termed chemotaxis - simple advection terms in the governing continuum model are typically used. In contrast to the classic models of bacteria chemotaxis by Keller and Segel for highly diffusive populations we consider advection-dominated travelling waves as models of dense motile cell populations.

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MS41
Stability of Concatenated Waves

Doug Ward (Drexel) and Sabrina Selle (Bielefeld) have studied stability of concatenated traveling waves, moving with different speeds, in dissipative systems. Their approach treats concatenated waves as a sum of waves. I will describe an alternate approach that respects the concatenated wave structure and uses Laplace transforms to solve the linearized problem.

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MS41
Transonic Evaporation Waves in a Spherical Symmetric Nozzle

We study the liquid to vapor phase transition in a cone shaped nozzle. Using geometric singular perturbation theory, we extend results on subsonic and supersonic evaporation waves by Fan and Lin (2011) to transonic waves. We are able to show the existence of evaporation waves that cross from supersonic to subsonic regions and evaporation waves that connect from the subsonic regions to the sonic surface and then continue onto the supersonic branch via the slow flow.

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MS43
Modeling Landslides and Landslide-generated Tsunamis

Landslide-generated tsunamis pose a significant threat, yet assessing their potential is challenging due to an unconstrained source. Dynamically modeling landslides can elucidate the tsunamigenic nature of offshore geomorphology, but this remains a difficult endeavor due to the complicated physics of granular-fluid flows. I will describe a two-phased depth-averaged model for tsunamigenic landslides. The model is a nonconservative system of hyperbolic equations similar to the shallow water equations.

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MS43
A Probabilistic Tsunami Hazard Assessment Study of Crescent City, Ca

A probabilistic tsunami hazard assessment (PTHA) of Crescent City, CA will be presented. The study is based on nonlinear tsunami inundation simulations with initial conditions corresponding to near- and far-field earthquake sources in the Cascadia, Alaska, Japan-Kamchatka-Kurile and Chile Subduction Zones. The methodology produces maps that provide an estimate of the maximum flood level that will be exceeded with a specific annual probability at each cell of the inundation computational grid.

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MS43
Simulation of Landslide-Generated Tsunamis with the Hysea Platform: the Lituya Bay 1958 Event

We present a multi GPU implementation of the IFCP FV scheme of the two-layer Savage-Hutter type model developed by E. D. Fernández-Nieto et al (JCP, 2008) to study submarine avalanches. In this model, a layer composed of fluidized granular material is assumed to flow within a layer composed of an inviscid fluid. A new web-based platform named HySEA is used as interface for simulating landslide-generated tsunamis focusing in the Lituya Bay 1958 mega-tsunami event.

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MS43
Detecting Standing Waves in Modeled Tsunami Wave-Fields

Continental shelves can serve as a barrier protecting from tsunami, or as a resonator trapping tsunami wave energy in standing waves. Bathymetric features in an adjacent ocean can also contribute to standing wave formation by acting as waveguides. Knowing how tsunami wave energy is transferred from the open ocean into oscillations next to the coast, and the spatial distribution of those oscillations, helps identify areas likely to experience the greatest amplitudes. We demonstrate techniques that use tsunami simulations to determine an area's resonance characteristics.

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MS43
Three-dimensional Tsunami Runup with GPUSPH

Abstract not available at time of publication.

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MS44
Laser Light Condensation Phenomena

We present in a theoretical and experimental study various condensation phenomena in cw and mode-locked lasers. They are based on weighting the laser modes in a noisy environment (spontaneous emission, etc.) by a loss-gain scale rather than in photon energy. They are characterized by a sharp transition from multi- to single-mode oscillation. The study uses a simple linear multivariate Langevin formulation with a global constraint which gives a mode occupation hierarchy that functions like Bose-Einstein statistics. We also discuss how and when condensation occurs in photon systems, how it relates to lasing, and the difficulties to observe regular photon Bose-Einstein condensation (BEC) in laser cavities.

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MS44
Phase-coherent Repetition Rate Multiplication of a Mode-locked Laser by Injection Locking

We have used injection locking to multiply the repetition rate of a passively mode-locked femtosecond fiber laser from 40 MHz to 1 GHz while preserving optical phase coherence between the master laser and the slave output. The slave system is implemented almost completely in fiber and incorporates gain and passive saturable absorption. The slave repetition rate is set to a rational harmonic of the master repetition rate, inducing pulse formation at the least common multiple of the master and slave repetition rates.

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MS44
The Sinusoidal Ginzburg-Landau Equation for High-Energy Mode-Locking

The sinusoidal Ginzburg-Landau Equation (SGLE) is presented to characterize the pulse evolution in a passively

mode-locked ring cavity laser. The model gives a better description of the cavity dynamics by accounting explicitly for the full periodic transmission generated by the wave-plates and polarizer. The SGLE agrees well with the full governing model, and it supports high energy pulses that are not predicted by the master mode-locking theory, thus providing a platform for optimizing the laser performance.

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MS44

Ultra-short Pulse Dynamics Towards Modeling Atto-second Physics

A new theoretical model is proposed for characterizing the ultrashort (few femtoseconds and below) propagation dynamics in a laser cavity that is mode-locked with a saturable absorbers. The theory circumvents the standard, and problematic, center frequency expansion methods that typically result in the nonlinear Schrodinger based master mode-locking equation. The resulting short-pulse equation framework, which is the equivalent of the nonlinear Schrodinger equation for ultrafast pulses, provides an asymptotically valid description of the electric field amplitude even as pulses are shortened below a single-cyle of the electric field. Given the lack of theory in the ultrafast regime, the model provides the beginning theoretical framework for quantifying the pulse dynamics and stability as pulsewidths approach the attosecond regime.

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MS45

Two-dimensional Nonlinear Internal Waves

Large amplitude internal solitary waves excited typically by the interaction of tidal currents with bottom topography have been observed frequently in coastal oceans through in-situ measurements and satellite images. Although there has been a considerably intensive research on nonlinear internal waves, most of the existing work is devoted strictly to the one-dimensional case. To study the evolution of two-dimensional large amplitude internal waves in a two-layer system with variable bottom topography, we derive a fully two-dimensional strongly nonlinear model. This is a generalization of the one-dimensional model of Choi, Barros & Jo (2009) that is known to be free from shear instability for a wide range of physical parameters. After investigating shear instability of the regularized model for ?at bottom, weakly two-dimensional and weakly nonlinear limits are discussed.

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MS45

Stable Solitary Waves in Two-layer Flows

The system of equations describing nonlinear and weakly dispersive interfacial waves between two layers of inviscid fluids of different densities and bounded by top and bottom walls is known to be mathematically ill-posed despite the fact that physically stable internal waves have been observed. We obtain a stable nonhydrostatic model for this system and illustrate our results with solitary waves.

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MS45

Strongly Nonlinear Interaction of Crossing Large Amplitude Internal Waves

A regularized model was introduced recently to describe strongly nonlinear internal waves in a two-layer system to eliminate the shear instability at the interface. The two-dimensional time evolution equations for the interface and velocity fields are solved numerically using a pseudo-spectral method to study the strongly nonlinear interaction of crossing internal solitary waves. Our simulations are compared with the solution of the weakly nonlinear KP equation.

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MS45

Modeling Three Dimensional Gravity-capillary Waves in Deep Water

Gravity-Capillary waves enjoy a range of applications. In order to accurately compute complex time dependent solutions, we simplify the full Euler equations by taking a cubic truncation of the Dirichlet-to-Neumann operator for the velocity potential on the free surface with the full surface tension. This equation agrees remarkably well with the full equations of solitary waves. In 3d, fully localised solitary waves are computed and the stability, interaction and focussing phenomena of both line and lump solitary waves are investigated via numerical time evolution, and some interesting dynamical phenomena are observed.

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MS45

Exact Solution of Linear Wave Motion Over Periodic Topography of Large Amplitude and Arbi-

trary Shape

We consider linear waves propagating over periodic topographies of arbitrary amplitude and wave form, generalising the method in Howard and Yu (2007). By a judicious construction of a conformal map from the flow domain to a uniform strip, exact solutions of Floquet type can be developed in the mapped plane. These Floquet solutions are analogous to the complete set of flat-bottom wave and evanescent modes, therefore can be used to construct the solutions to boundary value problems involving a wavy topography with a constant mean water depth. Various concrete examples are given and quantitative results are discussed. Comparisons with experimental data are made, and qualitative agreement is achieved. This is a collaboration with Louis N Howard at MIT. Support of JY by NSF (Grants CBET-0756271 and CBET-0845957) is acknowledged.

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MS46

Modulational Stability for a General Class of Dispersive Waves

Abstract: We consider a very general class of dispersive wave equations having a variational structure of the following form: there are two conserved quantities, a Hamiltonian and a Momentum, and a conserved Casimir, a Mass, along with some scaling relations. This includes a number of models describing water waves. Under these assumptions the stability of long waves is governed by a common normal form, and the modulational stability of such waves can be determined rather generally.

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MS46

Spectral Stability of Water Waves: Stable, High-Order Computation in the Presence of Resonance

We study spectral stability of periodic traveling waves in fluids in two dimensions. Rather than simply substituting a computed traveling wave into the linearized water wave problem and appealing to a numerical solver, we use the fact that waves come in analytic branches to show that, generically, the spectral data can also be parametrized analytically. We followed the behavior of the spectrum in the complex plane as a wave height/steepness parameter was increased until divergence of the method. The singularities in the expansions (resulting in the divergence of the numerical scheme) are mandated by the form of the expansions: only purely imaginary eigenvalues can be produced so that the algorithm cannot compute spectrum with a non-zero real part. In the light of this, we pose a conjecture that not only is the presence of a singularity necessary for the onset of (spectral) instability, but it is also sufficient. After careful numerical investigation, we find that the conjecture is largery justified in the case of deep water but unpredicts the onset of instability in shallow water.

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MS46

Stability and Bifurcations of Rotating Vortices in the Gross-Pitaevskii Equation with a Harmonic Potential

We show that the rotating symmetric vortices located at the center of a two-dimensional harmonic potential undertake a pitchfork bifurcation with radial symmetry. This bifurcation leads to the family of vortices, which precess constantly along an orbit enclosing the center of symmetry. The radius of the orbit depends on the precessional frequency, or equivalently, on the chemical potential. We show that both symmetric and asymmetric vortices are spectrally stable with respect to small time-dependent perturbations. At the same time, the symmetric vortex becomes a local minimizer of energy in the parameter region where the asymmetric vortex exists, the latter corresponds to a saddle point of energy.

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MS46

Asymptotic Stability of Semi-Strong Interactions in Weakly Damped Systems: Attack of the Point Spectrum

We demonstrate the asymptotic stability of semi-strong N-pulse solutions for a class of singularly perturbed reaction diffusion equations. The key step to both the existence and stability is the analysis of a family of non-self adjoint eigenvalue problems, particularly the control of the point spectrum, which we show breaks into a controllable part and a 'semi-strong' portion, which is amenable to an analytic reduction. This is joint work with Tom Bellsky.

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MS47

Bifurcations of Front Solutions for a Three-component Reaction Diffusion System

By means of a center manifold type reduction we derive an ODE system describing the evolution of front solutions in a three-component reaction-diffusion system. The reduced systems exhibits a surprisingly complicated bifurcation structure including a butterfly catastrophe and a Bogdanov-Takens type scenario. These results shed light on numerically observed accelerations and oscillations and pave the way for the analysis of front interactions in a parameter regime where the essential spectrum of a single front approaches the imaginary axis asymptotically.

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MS47

Blowup of Solitary Waves of the Generalised Korteweg-de Vries Equation

We study blowup solutions of the generalized Korteweg-de Vries equation (GKdV). These solutions arise when a soliton turns unstable and then becomes infinite in finite time; in other words blow up. Through a dynamical rescaling we reduce the GKdV to an ODE. Then, we use asymptotic methods and matching techniques to construct bounded solutions of the ODE. Moreover, with the asymptotic analysis we determine the parameter range over which these solutions may exist.

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MS47

Pulse Stability in a Gierer-Meinhardt System with a Slow Nonlinearity

The existence and stability of localized pulses in a Gierer-Meinhardt equation with an additional 'slow' nonlinearity is studied. This system is an explicit example of a general class of singularly perturbed , two-component reaction-diffusion equations that goes beyond model systems such as Gray-Scott and Gierer-Meinhardt. The additional nonlinearity influences the stability analysis and stability properties of the pulse. Moreover, unlike in GS/GM type models, pulse solutions exhibit complex behaviour near Hopf bifurcations.

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MS47

Destabilizing of Stationary Spots in a Planar Three-component FitzHugh-Nagumo Equation

In this talk, I will analyze the destabilization of a stable stationary radially symmetric spot arising in a specific planar three-component FitzHugh-Nagumo equation. In particular, I am interested in the bifurcation of the stationary spot to a traveling spot. As it turns out, there is a competition between this drift bifurcation and several other Hopf bifurcations. I will formally determine asymptotic conditions for these bifurcations and also check the asymptotic results with AUTO and a direct solver.

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MS48

Dark Breathers in Granular Crystals

We study the existence, stability and bifurcation structure of dark breathers in a one-dimensional uniform chain of beads under precompression. We derive a defocusing nonlinear Schrödinger equation (NLS) for frequencies that are close to the edge of the linear spectrum and use this to construct targeted initial conditions to numerically find the dark breather solutions. The range of validity of the NLS approximation is also explored and we discuss experimental implications of our results.

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MS48

Topological and Spectral Features of Nonlinear Wave Motion in Periodic Chains

Wave motion in periodic chains with cubic nonlinearities is investigated with the objective of providing a comprehensive account of the distinctive topological and spectral features of one-dimensional nonlinear wave propagation. The investigation focuses on analogies and differences between nonlinear chains and their linear dispersive counterparts, as well as on the interplay and competing roles of dispersive and nonlinear mechanisms in the formation and classification of wave distortion. The signatures of salient behavior associated with nonlinear mechanisms are collected both in the physical (space-time) and spectral (frequency-wavenumber) space, and the special case of waves with identical spectral content and markedly different topologies in the physical space is investigated. The analysis is carried out using full-scale simulations in conjunction with a variety of global and local signal processing techniques, and the results are checked against existing unit-cell based perturbation methods.

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MS48

Ill-posedness of a Linearized Compacton Equation

After linearizing the $K(2,2)$ equation around a known periodic solution (whose spacial truncation is the famous compacton solution), we are able do demonstrate that the spectrum of the linear operator, as an operator on $H^3([-\pi,\pi])$, is the entire complex plane. This is accomplished by turning the eigenvalue value problem into a discrete dynamical system which we then solve. We will also briefly consider the operators that arise as linearizations of the $K(n,m)$ equation.

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MS48

Ill-Posedness Due to Degenerate Dispersion

We study the behavior of solutions for PDEs with degenerate dispersions. Using the degenerate Airy equation

$u_t = 2uu_{xxx}$ as an example, we show that unlike uniform dispersive effects, degenerate dispersion even just by itself may lead to ill-posedness of the corresponding initial value problem. In particular, we establish the existence of a compactly supported self-similar solution for the degenerate Airy equation. When combined with certain scaling invariances, such a self-similar solution implies that the degenerate Airy equation is ill-posed for initial data in H^2, i.e., its solutions do not depend smoothly on initial conditions.

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MS49

Threshold Models and Abrupt Change in Social Norms in Complex Social Networks

In our work we seek for description of extensive simulations and mathematical analysis of simple systems of people affected by both personal preferences and observation of their neighbors behaviour. We show that the influential Schelling-Granovetter model of threshold behavior change is equivalent to a zero-temperature, mean-field limit of a very well studied model in physics the Ising model. We also show that we can study the effects of locality and mixing rate on behavior change by studying these models on lattices and networks.

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MS49

An Adversarial Evolutionary Game for Criminal Behavior

We consider an adversarial evolutionary game developed for criminal activity where players may or may not commit crimes and cooperate with authorities. Among the four possible player strategies, the so called "informant" who cooperates while still committing crimes. We find two possible equilibration regimes, a defection-dominated and an ideal, cooperation-dominated one and show that the number of informants is crucial in determining which of these two regimes is achieved.

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MS49

Towards Simulating Societies: Simple Models with Complex Dynamics

In order to understand social systems, it is essential to identify the circumstances under which individuals spontaneously start cooperating or developing shared behaviors, norms, and culture. In this connection, it is important to study the role of social mechanisms such as repeated interactions, group selection, network formation, costly punishment and group pressure, and how they allow to transform social dilemmas into interactive situations that promote the social system. Furthermore, it is interesting to study the role that social inequality, the protection of private property, or the on-going globalization play for the resulting "character" of a social system (cooperative or not). It is well-known that social cooperation can suddenly break down, giving rise to poverty or conflict. The decline of high cultures and the outbreak of civil wars or revolutions are well-known examples. The more suprising is it that one can develop an integrated game-theoretical description of phenomena as different as the outbreak and breakdown of cooperation, the formation of norms or subcultures, and the occurence of conflicts.

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MS49

Social Interactions on Networks: Self-excitation, Third-party inhibition, and the Link with Game Theory

We introduce a point process model for social interactions on a network, including self-excitation and third-party inhibition. Here, a coupled system of state-dependent jump stochastic differential equations is used to model the conditional intensities of the directed network of interactions. The model produces a wide variety of transient or stationary weighted network configurations and we investigate under what conditions each type of network forms in the continuum limit. We also explore the link between this model and recent work on repeated games.

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PP1

Some Exact Solutions Of Two 5th Order KdV-Type Nonlinear Evolution Equations

We consider the generalized 5th order nonlinear KdV equation which is invariant under a scaling transformation with suitable weighting scheme. An extension of tanh method has been used rigorously for solving this fifth order nonlinear evolutionary partial differential equation. The general solutions of the parameters are formed considering an ansazt of the solution in terms of tanh. Then, using these results some exact solutions are found for the two 5th order KdV-type equations which also include soliton solutions.

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PP1

Compressed Sensing in Retinal Image Processing

Retinal image processing transforms photons into membrane potentials via several nonlinear transformations. This process begins in a large network of photoreceptors and ends in a relatively small ganglion cell network. We posit the loss of visual information despite the decrease in network size is minimized via compressed sensing. Using an idealized mathematical model of the retina and a mean-field analytical reduction, we demonstrate firing patterns among ganglion cells can be used to reconstruct input images.

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PP1

Computational Reductions and Dynamics of Neuronal Models with Adaptation Current

The stiffness and complexities associated with the nonlinearities of the Hodgkin-Huxley neuron model have motivated a wide array of computational reductions. The dynamical systems underlying these reductions, however, rarely generalize to neurons containing realistic adaptive ionic currents. Using several numerical simulations and associated measures of robustness, we demonstrate that our novel modeling algorithm accomplishes the goals of attaining accuracy and efficiency while retaining enough generality to replicate the nontrivial dynamics of specialized neurons.

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PP1

Simultaneous Frequency Conversion, Regeneration and Reshaping of Optical Signals

Nondegenerate four-wave mixing in fibers enables the tunable and low-noise frequency conversion of optical signals. This poster shows that four-wave mixing driven by pulsed pumps can also regenerate and reshape optical signal pulses arbitrarily.

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PP1

A Numerical Method For Solving Nonlinear Schrodinger Equation

The Finite-Difference Time-Domain (FDTD) method is a well-known technique for the analysis of quantum devices. It solves a discretized Schrodinger equation in an explicitly iterative process. In this research, we apply the idea of the FDTD method to the development of a numerical method for solving the time dependent nonlinear Schrodinger equation. The scheme is shown to satisfy the discrete energy conservation laws. Finally, the scheme is tested by simulating the propagation and formation of solitons.

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PP1

Fifth Order Evolution Equation for Long Wave Dissipative Solitons

Solitary waves may arise in systems with dissipation and instability if a balance between these effects and nonlinearities exists. We search for a consistent model equation to describe long wave dissipative solitons including fifth order dispersion. The equation found includes quadratic and cubic nonlinearities. For certain parameter values the bifurcation from the basic state is subcritical. In this case we show that periodic solutions in a small box do not blow up in finite time.

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PP1

Feigenbaum Universality, Lyapunov Exponents and Fractal Dimensions in Two Dimensional Chaotic Models

This paper highlights the following objectives in some two dimensional chaotic models: (i) Sophisticated numerical methods have been developed to determine Feigenbaum bifurcation tree leading to chaos, (ii)Determination of Lyapunov exponents, Correlation, box- counting and information dimensions as measure of chaos (iii) Statistical tools are employed to confirm the results .

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PP1

Confinement of the Eigenvalues of the Ablowitz-

Ladik Eigenvalue Problem.

Klaus and Shaw (2001) proved that if initial conditions for the Nonlinear Schrödinger equation were real and single-lobe, the eigenvalues of the Zakarov-Shabat system should be imaginary. To the knowledge of the authors, there is no analogous to discrete problems. The natural extension for this result is that if the single-lobe property was satisfied by the potentials of the Ablowitz-Ladik (AL) eigenvalue problem, then the eigenvalues should be real. We show an extension of Klaus-Shaw potential for the AL lattice.

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PP1

On the Nonlinear Schrodinger Equation with Embedded Eigenvalues

We revisit the inverse scattering transform for the one-dimensional focusing nonlinear Schrodinger equation with zero boundary conditions at infinity. Explicitly, we study cases in which the analytic scattering coefficients admit zeros on the real axis. We present specific examples and we discuss the appropriate formulation of the inverse problem, issues of existence and uniqueness and the long-time behavior of the solutions.

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PP1

Travelling Waves of a Reaction-Diffusion Model for the Acidic Nitrate-Ferroin Reaction

We consider a system of two reaction-diffusion equations, which was derived to model the acidic nitrate-ferroin reaction. The existence and stability of travelling waves for this system are investigated. The proofs for the obtained results are rigorous.

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PP1

Random and Regular Dynamics of Stochastically Driven Neuronal Networks

Dynamical properties of and uncertainty quantification in Integrate-and-Fire neuronal networks with multiple time scales of excitatory and inhibitory neuronal conductances driven by random Poisson trains of external spikes will be discussed. Both the asynchronous regime in which the network spikes arrive at completely random times and the synchronous regime in which network spikes arrive within periodically repeating, well-separated time periods, even though individual neurons spike randomly will be presented.

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PP1

Vaccinating Against HPV in Dynamic 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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PP1

A Hamiltonian Water Wave Model with Horizontally Sheared Currents

We will show the Hamiltonian dynamics of a new, variational water wave model of Cotter and Bokhove (2010). This model has a threedimensional velocity ?eld consisting of the full threedimensional potential ?eld plus horizontal velocity components, such that the vertical component of vorticity is nonzero. We aim to augment the new model locally with bores and will discuss how our existing variational, potential-flow ?nite element model can be extended to include bores.

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PP1

Many-Body Interaction in Fast Collisions of Nls Solitons

We study the effects of fast collisions between NLS solitons in the presence of weak nonlinear loss $-\epsilon|\psi|^{2m}\psi$. We show that for $m \geq 2$, n-body interaction with $m+1 \geq n \geq 3$ gives a significant contribution to the collision-induced amplitude shift. We characterize the dependence of this contribution on m, n, the group velocity difference, and the initial soliton positions.

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PP1
Dynamics of a Mean Field Cortex Model

We study a PDE model of the membrane potential and synaptic interaction of excitatory and inhibitory neuron populations in a two-dimensional slab of cortical tissue. Considering the equations as an autonomous dynamical system, we aim to parse the model using bifurcation analysis. We compute equilibria, waves, and periodic patterns, and study their dependence on external input, connectivity parameters and the domain size. Our computations are done using open source code built on PETSc.

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PP1
Pattern Competition in Spatially-Forced Systems

Spatial periodic forcing of pattern-forming systems is an important, but lightly studied, method of pattern control. Forcing can be used to control the wavenumber of one-dimensional periodic patterns, to increase pattern amplitudes, to stabilize unstable patterns, or to induce patterns below instability onset. We show how in one spatial dimension forcing acts to reinforce patterns, while in two dimensions it acts to destabilize or displace them by producing two-dimensional rectangular and oblique patterns.

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PP1
A Slow Pushed Front in a Lotka-Volterra Competition Model

We study the existence and stability of a traveling front in the Lotka-Volterra competition model when the rate of diffusion of one species is small. This front is noteworthy in two respects. First, we show that it is the selected, or critical, front for this system. We utilize techniques from geometric singular perturbation theory and geometric desingularization. Second, we show that this front is a pushed front despite the fact that it propagates slower than the linear spreading speed.

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PP1
Stability and Dynamics of Solitary Waves in Bec Spinor Lattices

The work presented in this talk focuses on understanding solitary waves in a spinor BEC lattice system. This system is motivated by the spinor BEC which can be described by a quasi-one dimensional model. Here, we discuss two- and three-component dynamical lattice which contains a mean field nonlinearity. Our analysis of solitary waves involves (i) an examination of the anti-continuum limit for our model of interest, (ii) the existence and stability of these solitary waves via a perturbative approach and (iii) understanding the structure of these waves in excited sites of the lattice.

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PP1
Weakly Subcritical Stationary Patterns: Eckhaus Instability and Homoclinic Snaking

The transition from subcritical to supercritical stationary periodic patterns is described by the one-dimensional cubic-quintic Ginzburg-Landau equation $A_t = \mu A + A_{xx} + i(a_1|A|^2 A_x + a_2 A^2 A_x^*) + b|A|^2 A - |A|^4 A$, where $A(x,t)$ represents the pattern amplitude and the coefficients μ, a_1, a_2 and b are real. The conditions for Eckhaus instability of periodic solutions are determined, and the resulting spatially modulated states are computed. Some of these evolve into spatially localized structures in the vicinity of a Maxwell point, while others resemble defect states. The results are used to shed light on the behavior of localized structures in systems exhibiting homoclinic snaking during the transition from subcriticality to supercriticality.

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PP1
Localized Structures in Rotating Convection

Convection in a horizontal layer heated from below and rotating about the vertical is studied. The system admits 2D spatially localized structures. Such structures are organized in the form of slanted snaking and are present over a large range of Rayleigh numbers, regardless of the direction of branching of periodic convection. This behavior is a consequence of a conserved quantity. The results are compared with predictions based on a fifth order amplitude equation. This is joint work with C Beaume (IMFT), A Bergeon (IMFT) and H-C Kao (UC Berkeley).

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PP1
Gain-Controlled Soliton Routing in Dissipative Lattices.

We demonstrate an effective mechanism for gain-controlled soliton routing in dissipative lattices. An effective particle model reveals the essential features of soliton dynamics in such structures. The results presented are directly applicable to general inhomogeneous systems where interplay between gain and loss mechanisms occurs. Focusing on the complexity of soliton dynamics rather than on the complexity of their profiles we have analyzed scenarios that are promising for dynamical soliton control concepts and applications.

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PP1
Mutual Interactions Between Electromagnetic Solitons in Plasmas

We numerically investigate the mutual interactions between two electromagnetic solitons in a cold unmagnetized plasma, both for finite and vanishing group speeds of the interacting structures. The interaction of two spatially overlapping standing electromagnetic solitons is studied for partial as well as complete overlap and the corresponding end states are compared.

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PP1
Synchronous and Asynchronous Dynamics of Complex Neuronal Networks

For integrate-and-fire neuronal networks with complex connectivity topology, we study the dependence of their pulse rate on the underlying architectural connectivity statistics. We derive the distribution of the firing rate from this dependence and determine when the underlying scale-free architectural connectivity gives rise to a scale-free pulse-rate distribution. We identify the scaling of the pairwise coupling between the dynamical units in this network class that keeps their pulse rates bounded in the infinite-network limit.

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PP1
Spatiotemporal Dynamics in Three Species Model Systems with Self Diffusion

Input your abstract, including TeX commands, here. In this paper, the complex dynamics of two types of tritrophic food chain model systems modeling two real situations of marine ecosystem have been investigated in the presence of diffusion, both analytically and through numerical simulations. These models have been studied earlier, but in the absence of diffusion. The numerical simulation leads to spontaneous and interesting pattern formation. Diffusion driven analysis is carried out and effect of diffusion on the chaotic dynamics of the model systems are studied. The existence of chaotic attractor and long term chaotic behavior demonstrate the effect of diffusion on the dynamics of the model systems

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PP1

Localized Patterns on the Surface of a Magnetic Fluid

The discovery of two-dimensional solitons on the surface of a ferrofluid under a vertical magnetic field by Richter and Barashenkov (PRL, 2005) has raised many new theoretical questions. Due to the complicated nature of the equations modelling ferrofluids, Richter and Barashenkov proposed a conservative analogue of the Swift-Hohenberg equation

$$u_{tt} = -(1+\Delta)^2 u - \nu u + \mu u^2 - u^3, \tag{1}$$

as a phenomenological model that could provide an understanding of localised axisymmetric solitons. Here, $u = u(x, y, t)$ describes the surface height, ν is related to the strength of the magnetic field (and is the usual control parameter) and μ is related to the permeability of the ferrofluid. Here, we review what is known about stationary (time-independent) solutions of the equation above and show where this phenomenological model is (un)successful in predicting the qualitative nature of localised patterns on the surface of a ferrofluid. Furthermore, we show numerically that homoclinic snaking does exist in the full Ferrofluid equations.

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PP1

Transition Between Slow and Fast Wavefronts from the Point of View of Speed Selection

On an example of a system of coupled reaction-diffusion equations, we discuss a sudden transition between slow and fast wavefronts. We relate the mechanism of such transition to the known facts about speed selection for fronts.

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PP1

Oscillons Near Forced Hopf Bifurcations

Oscillons are planar, spatially localized, temporally oscillating, radially symmetric structures. We present a proof of the existence of oscillons in the forced planar complex Ginzburg-Landau equation through a geometric blow-up analysis. Our analysis is complemented by a numerical continuation study of oscillons in the forced Ginzburg-Landau equation using Matlab and AUTO.

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PP1

Bistable Fronts in Discrete Inhomogeneous Media

Bistable differential-difference equations with inhomogeneous diffusion are considered using McKean's caricature of the cubic. Front solutions are constructed for essentially arbitrary inhomogeneous discrete diffusion and these solutions correspond, in the case of homogeneous diffusion, to monotone traveling front solutions, or stationary front solutions in the case of propagation failure. Explicit conditions reveal relationships between zero wave speed and defects in the medium, and changes in wave speed and shape are analyzed as fronts propagate.

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PP1

Numerical Simulation of Internal Wave Generation from a Collapsing Mixed Region in Stratified Fluid

The dynamics of a density perturbed fluid into an ambient fluid with complex stratification is examined by numerical simulations. Algorithms based on the Navier-Stokes equations in the primitive variables and on the Eulerian-Lagrangian coordinate system and moving grid are utilized. High-order, monotone approximation of convective terms are used. Parametric calculations demonstrated the applicability of the numerical models. The analysis focuses upon the generation and propagation of internal waves and on the dynamics of collapsing region.

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PP1

Synchrony in Stochastic Pulse-Coupled Neuronal Network Models

We are interested in the synchronous dynamics of simple pulse-coupled models for neuron dynamics. These time correlations in firing times are seen experimentally. In our model, the size of synchronous firing events depends on the probabilistic dynamics between such events as well as the network structure representing the neuron connections. We presents both analytical results and numerical simulations of these global dynamics.

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PP1

An Improved Local Well-Posedness Result for the Periodic "Good" Boussinesq Equation.

We prove that the "good" Boussinesq model with the periodic boundary condition is locally well-posed in the space $H^s \times H^{s-2}$ for $s \geq -3/8$. In the proof, we employ the normal form approach, which allows us to explicitly extract the rougher part of the solution. This also leads to the conclusion that the remainder is in a smoother space $C([0;T];H^{s+a})$, where $0 \leq a < min(2s+1;1/2)$. If we have a mean-zero initial data, this implies a smoothing effect of this order for the non-linearity. This is new even in the previously considered cases $s > -1/4$.

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PP1

Effects of Stochastic Perturbations on the Atlantic Thermohaline Circulation

The Atlantic thermohaline circulation (THC) transports large amounts of heat from the equatorial region northward toward the polar regions and is responsible for the relatively mild climate in the north Atlantic. Various studies have shown the Atlantic THC can have multiple stable equilibria each representing very different climatic states. Stochastic ODEs are derived from simple box models and we will show how stochastic perturbations such as freshwater influx can produce transitions between these equilibria.

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PP1

The Extension of the Generalized Regularized Long Wave Equation

The Regularized Long-Wave equation, also known as the Benjamin-Bona-Mahony (BBM)-equation was first studied as a model for small-amplitude long waves that propagate on the free surface of a perfect fluid. As an alternative to the Korteweg-de Vries equation, it features a balance between nonlinearity and a frequency dispersion term that allows the existence of traveling waves that are smooth and symmetric about their maximum. Such waves decay rapidly to zero on their outskirts and, because of their tendency to travel alone, are known as 'solitary waves'. We investigate the behavior of solitary-wave solutions for the Extended BBM (EBBM)-equation which is the BBM-equation, but with two power nonlinearities in general, gradient form. We prove that this model is globally well-posed, which provides a rigorous foundation for the stability theory of their solitary-wave solutions. Since solitary-wave solutions of the EBBM-equation are not known analytically, they are generated and investigated numerically. It transpires that there can be as many as three stability regimes for the EBBM-solitary waves. We present numerical simulations of the formation and long-time evolution of solitary waves, the behavior of solitary waves under amplitude perturbations and the interaction of solitary waves. Minimal perturbations necessary to force a solitary wave to change stability regimes are also determined.

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PP1

Complex Soliton Dynamics in Lattices with Longitudinal Modulation

Soliton dynamics in a large variety of longitudinally modulated lattices are studied in terms of phase-space analysis for an effective particle approach and direct numerical simulations. A rich set of qualitatively distinct dynamical features of soliton propagation that have no counterpart in longitudinally uniform lattices is illustrated. This set includes cases of enhanced soliton mobility, dynamical switching, extended trapping in several transverse lattice periods, and quasiperiodic trapping, which are promising for soliton control applications.

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PP1

Point vortex equilibria and Calogero-Sutherland equation

We consider linear evolution flows on the space of polynomials and compute the associated dynamics of the polynomial roots . This leads to a set of equations for the root dynamics, whose equilibria are used to compute relative equilibria for the point vortex problem in 2-D fluids. We make use of properties of the Calogero-Sutherland model in two variables to construct novel point vortex confingurations.

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PP1

Snakes and Ladders: Stability of Fronts and Pulses

The subject of this poster are localized patches composed of spatially periodic structures. These patterns often exhibit snaking: in parameter space, the localized states lie on a vertical sine-shaped bifurcation curve so that the width of the underlying periodic pattern increases as one moves up along the bifurcation curve. The issue addressed here is the stability of these structures as a function of the bifurcation parameter.

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PP1

On the Spectral Stability of Soltion Solutions of the Vector Nonlinear Schrödinger Equation

We consider a system of coupled cubic nonlinear Schrödinger (NLS) equations

$$i\frac{\partial \psi_j}{\partial t} = -\frac{\partial^2 \psi_j}{\partial x^2} + \sum_{k=1}^{n} \alpha_{jk}|\psi_k|^2\psi_j \qquad j = 1, 2, \ldots, n$$

where $\alpha_{jk} = \alpha_{kj}$ are real. The stability of solitary wave solutions is examined numerically using Hill's method (Deconinck, B. and J. N. Kutz. J. Comput. Phys., 219: 296-321, 2006). Our results extend the analysis of Nguyen (Commun. Math. Sci., 9: 997-1012, 2001.) to incorporate solitons with nontrivial phase profile.

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PP1

On Model of Short Pulse Type in Continuous Media

We consider short pulse propagation in nonlinear metamaterials characterized by a weak Kerr-type nonlinearity in their dielectric response. We derive two short-pulse equations (SPEs) for the high- and low-frequency band for 1 dimensional case. Then we generalize this into 2 dimensional case and give a 2D version of the short pulse equation. For 1D soutions, we will discuss the connection with the soliton solution of the nonlinear Schrödinger equation, also we will discuss the robustness of various solutions emanating from the sine-Gordon equation and their periodic generalizations. For the 2D short pulse equation, we will discuss several possible forms and their solutions.

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PP1

Global Existence for a System of Schrödinger Equations with Power-Type Nonlinearities

We consider the Cauchy problem for a Schrödinger system with power-type nonlinearities

$$\begin{cases} i\frac{\partial}{\partial t}u_j + \triangle u_j + \sum_{k=1}^{m} a_{jk}|u_k|^p|u_j|^{p-2}u_j = 0, \\ u_j(x,0) = \psi_{j0}(x), \end{cases}$$

where $u_j : \mathbf{R}^N \times \mathbf{R} \to \mathbf{C}, \psi_{j0} : \mathbf{R}^N \to \mathbf{C}$ for $j = 1, 2, ..., m$ and $a_{jk} = a_{kj}$ are real numbers. Global existence is first established for $\frac{3}{2} \leq p < 1 + \frac{2}{N}$. Then we deduce a sharp form of vector-valued Gagliardo-Nirenberg inequality and use it to prove global existence in the critical case for small initial data. At the end, we consider the stability of solutions in the critical case.

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PP1

A Single Equation Describing Free Surface Water Waves.

Zakharov (1968) introduced canonical coordinates for the free surface water wave equations. Using the same canonical coordinates on the formulation of the water wave problem due to Ablowitz, Fokas and Musslimani (2006), we derive a single nonlinear complex equation describing the dynamics of the free surface. In contrast to Zakharov's equation, our equation is not restricted to waves of small amplitude. The properties of this equation are examined.

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PP1

Numerical Inverse Scattering: Uniform Approximation of Solutions of Integrable Pdes

Riemann–Hilbert problems arise in many different applications, ranging from integrable systems and special function theory to card-shuffling and random matrix theory. A recent collocation method allows for the numerical solution of Riemann–Hilbert problems. In this poster I will lay out how to use this method to, in effect, solve integrable equations on the whole line for arbitrary spectral data. Uniformity statements about the approximation can be proved. Additionally, this can be used to examine the validity of the known asymptotic formulas.

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PP1

Traveling Waves in a Simplified Model of Calcium Dynamics

We analyze traveling wave propagation in a simplified model of intracellular calcium dynamics. Despite its simplicity, the model is thought to capture fundamental features of wave propagation in calcium models. We explore aspects of the dynamics of traveling front, pulse and periodic wave solutions as J, a parameter in our model, is varied. We focus on the closed-cell version of the model, which corresponds to a singular limit of the full (open-cell) model. We use our results about the closed-cell model to make conjectures about the nature of wave solutions in the open-cell version of the model. A comparison between the properties of wave solutions of the calcium model and wave solutions of the FitzHugh-Nagumo equations reveals that the calcium model is an excitable system essentially different from the FitzHugh-Nagumo equations.

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PP1

Behaviour of Torsional Surface Wave in a Homogeneous Substratum over a Dissipative Half Space

The propagation behaviour of Torsional surface wave in a homogeneous isotropic layer lying over a viscoelastic half space has been taken into account. Numerical result has been obtained to show the effect of internal friction, rigidity and wave number on phase velocity of Torsional surface wave. Dispersion equation reduced in classical form when derived as a particular case. Graphical user interface (GUI) has been developed using MATLAB to generalize the effect of various parameter discussed.

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PP1

Propagation Failure in Discrete Periodic Media

We study the periodic lattice dynamical systems with bistable nonlinearity. We use Moser's Theorem to show that there exist infinitely many stationary solutions when one of the migration coefficients is sufficiently small. Moreover, we prove the propagation failure occurs when both migration coefficients are sufficiently small.

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PP1

Grain Boundaries in Swift-Hohenberg Equations

We investigate grain boundaries in the Swift-Hohenberg equation posed in the plane. In dimension 2, we show the existence of grain boundaries—stationary solutions which are even in x, periodic in y and approach rotated members of the family of stationary periodic patterns as x goes to infinity. Grain boundaries in this spatially extended system resembles defects commonly seen in physical experiments. We employ center manifold reduction and normal form theory to reduce the PDE to a finite-but high-dimensional ODE, in which we can locate heteroclinic orbits. Those correspond to grain boundaries in the Swift-Hohenberg equation.

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PP1

Stationary Nonlinear Modes and Beam Amplification in $\mathcal{PT}$-Symmetric Harmonic Potential

We report a number of unusual properties of stationary modes in the nonlinear Schroedinger equation with $\mathcal{PT}$-symmetric harmonic potential $x^2 - 2i\alpha x$. In particular, the modes, bifurcating from different eigenstates of the underlying linear problem, can actually belong to the same family of nonlinear modes. By proper adjustment of the coefficient α it is possible to enhance stability of nonlinear modes comparing to the case of real harmonic potential. Linear and nonlinear dynamics of the modes is also discussed.

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PP1

Multiple Solutions of Poisson-Nernst-Planck(pnp) Systems for Ion Channels

we consider a one-dimensional PNP model for ionic flow through ion channels for two ion species with permanent charges. The PNP model problem can be viewed as a boundary value problem of a singularly perturbed system and the existence of solutions is reduced to that of an algebraic system. Multiple solutions are shown to exist, under some conditions, through bifurcation analysis and numerical computations are consistent with our analysis. Existence of multiple solutions in such or similar models might be relevant to some complex behaviors of ion channels.

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