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IP1

Opening Remarks and Presentation: The Spatiotemporal Route to Turbulence

"What we really cannot do is deal with actual, wet water running through a pipe. That is the central problem which we ought to solve some day, and we have not." This statement by Richard Feynman captures how the seemingly simple motion of fluid through a pipe can present such an immense scientific challenge. After years of missteps, controversies, and uncertainties, we are at long last converging on a unified and fascinating picture of the transition to turbulence in flows such as pipes, channels, and ducts. What is remarkable about this story is the connection it has established to many other complex phenomena such as epidemics, wildfires, and neuron action potentials. We now understand that the route to turbulence in many flows occurs via spatiotemporal intermittency and falls in the class of non-equilibrium statistical phase transitions known as directed percolation. In this talk I will explain the big picture of why we care about the transition to turbulence. I will the describe the spatiotemporal nature of the problem and how universality manifests itself. Finally, I will present recent theoretical work aimed at capturing the origins of these phenomena.

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IP2

Breathers in PDEs and Lattice Systems

Breather solutions are spatially localized, temporally periodic solutions of partial differential equations and lattice systems. While common in lattice systems, they are rare for partial differential equations with constant coefficients but are known to exist in some PDEs with inhomogeneous coefficients. Breathers are important for understanding phenomena as distinct as localization of energy in extended systems and metastable dynamics. This talk will explore some of their applications, and discuss methods for proving their existence in different types of dynamical systems.

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IP3

Instability of Peaked Waves in Hydrodynamical Models

Stokes' wave is a traveling (periodic or solitary) wave with a stagnation point at its crest, where the surface of fluids has a peaked singularity. Stokes waves have been considered within Euler's equations and have been modeled by using reduced equations of motion such as the Camassa-Holm equation, the rotation-modified Ostrovsky equation, and other systems with wave breaking. I will overview the recent analysis of nonlinear, linear, and spectral instability of the traveling peaked waves in some reduced models such as the b-family of the Camassa-Holm equations. Well-posedness of the initial-value problem for this family holds in the energy space as long as the first spatial derivative (the wave slope) is bounded. We show that the travelling peaked waves are unstable due to wave breaking when the wave slope becomes unbounded in a finite time. This instability can also be studied by using the spectral stability analysis within the linearized equations of motion obtained consistently with the well-posedness results.

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IP4

Localised Structures in Reaction-Diffusion Systems for Cell Polarity Formation

Cell polarity formation is the process by which all eukaryotic cells develop their shape and form. It is widely believed that the process is controlled by small GTPases known collectively as rho-proteins (or ROPs in plants). Such proteins diffuse freely within the cell body in active form, but also diffuse more slowly in an activated form that is bound to the cell membrane. A number of mathematical models have been proposed for explaining the forms of patterns seen, typically in the form of reaction-diffusion systems of activator-inhibitor type, often involve cross-talk between several competing GTPase species. In this talk, I shall give an overview of mathematical and computational results on such systems, taking into account an interplay between dynamical systems theory and nonlinear analysis. Much is known about the case of long-thin cells, such as in the hair-producing cells in the epidermis of plant roots. Here under a 1D spatial approximation, we typically find subcritical Turing bifurcations that lead to the onset of spatially localised patterns via the so-called homoclinic snaking mechanism. I shall show connections to semi-strong asymptotic analysis and so-called wave-pinning theory. More recent results shall include joint work with recent PhD students Fahad Al Saadi and Edgardo Villar-Sepulveda among others, on extension to multi-component systems and to more realistic 3D geometries where the process is governed by bulk-surface PDE systems.

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IP5

Inverse Scattering Transform for Nonlinear Schrdinger Systems on a Nontrivial Background: A Survey of Classical Results, New Developments and Future Directions

In the last ten years, the inverse scattering (IST) as a tool to study integrable PDEs has seen a marked revival, with a flourishing of papers and applications devoted to the study of soliton interactions, semiclassical limits, long-time asymptotic behavior of solutions, and to the investigation of the integrable nature of modulational instability, integrable turbulence, soliton gases, connections to rogue waves and beyond. In this talk we will present a survey of classical and more recent results on the IST for one-dimensional scalar, vector and matrix nonlinear Schrdinger systems on the whole line with physically relevant non-zero boundary conditions at space infinity. We will also discuss some new developments and applications, in particular in regard to soliton interactions, rogue waves and long-time asymptotics, and offer some perspectives about future directions in the field.

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IP6

Closing Remarks and Presentation: Universal Dynamics of Damped-Driven Systems: The Logistic Map as a Normal Form for Energy Balance and Pattern Formation

Damped-driven systems are ubiquitous in engineering and science. Despite the diversity of physical processes observed in a broad range of applications, the underlying instabilities observed in practice have a universal characterization which is determined by the overall gain and loss curves of a given system. The universal behavior of damped-driven systems can be understood from a geometrical description of the energy balance with a minimal number of assumptions. The assumptions on the energy dynamics are as follows: the energy increases monotonically as a function of increasing gain, and the losses become increasingly larger with increasing energy, i.e. there are many routes for dissipation in the system for large input energy. The intersection of the gain and loss curves define an energy balanced solution. By constructing an iterative map between the loss and gain curves, the dynamics can be shown to be homeomorphic to the logistic map, which exhibits a period doubling cascade to chaos. Indeed, the loss and gain curves allow for a geometrical description of the dynamics through a simple Verhulst diagram (cobweb plot). Thus irrespective of the physics and its complexities, this simple geometrical description dictates the universal set of logistic map instabilities that arise in complex damped-driven systems. More broadly, damped-driven systems are a class of non-equilibrium pattern forming systems which have a canonical set of instabilities that are manifest in practice.

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SP1

Martin D. Kruskal and T. Brooke Benjamin Prize in Nonlinear Waves Award Presentations and Martin D. Kruskal Prize Lecture

To Follow

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CP1

Three Fold Structure in the Flow Past a Mounted Wedge

This talk is concerned with the simulation of a complex fluid flow problem involving flow past a wedge mounted on a wall for channel Reynolds numbers $Re_c = 1560$, 6621 and 6873 in uniform and accelerated flow medium. We are particularly interested in capturing the three stages of vortex shedding for the accelerated flow, leading to the exceedingly intricate three-fold structure. All the flow characteristics of the well-known laboratory experiment of Pullin and Perry (Some flow visualization experiments on the starting vortex. J. Fluid Mech., 1980, Vol. 97(2) pages :239-255) have been remarkably well simulated by our numerical simulation. Furthermore, we looked into the influence of the parameter m, which controls how much acceleration occurs, in detail. The simulation of the flow across a time span significantly greater than that of Pullin and Perry's experimental attempt is the current study's most noteworthy accomplishment. Flow features at the points of transition to turbulence have also been resolved. The existence of coherent structures in the flow validates the quality of our simulation, as does the remarkable similarity of our simulation to the high Reynolds number experimental results of Lian and Huang (Starting flow and structures of the starting vortex behind bluff bodies with sharp edges. Experiments in Fluids, 1989, Vol. 8(1-2) pages : 95-103) for the accelerated flow across a typical flat plate.

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CP1

Semilinear Viscoelastic Wave Equations with Local Memory-Dampings Concerning Oscillating Or Sign-Varying Kernels

In this work, we investigate the uniform decay rates for semilinear viscoelastic wave equations with local memory and frictional effects, where the memory damping only works on a part of the domain, and the memory function is not assumed to be a positive and decreasing function which means the memory kernel could be oscillating or sign-varying function. We establish an exponential stability theorem and an polynomial stability theorem for the viscoelastic wave equations with weak conditions on the kernel function and the adjustment coefficient function in the wave equations. Moreover, we obtain the integrability of the energy for the equations.

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CP1

Photonic Matrix Multiplier Makes a Lensless Direction Finding Sensor

Object detection is a fundamental task in sensing and information processing applications, as one can gather information such as the presence of nearby objects and their proximity. Indeed, Radars are commonly used to perform such tasks, but they have limitations in providing finer details due to the radiofrequency regime in which they operate. LiDARs, on the other hand, are a more suitable alternative as they can operate in shorter wavelengths (near-infrared), a regime widely used in telecommunications systems due to their low energy consumption and safety to the human eye. This talk introduces the design and analysis of a passive and fully optical on-chip direction-finding architecture, which can operate effectively in broad or narrow detection scenarios. The proposed system is based on an equally spaced linear array of M grating couplers that steer incoming waves toward a passive and non-unitary photonic processor. This performs a processing operation from which the incident angles of the incoming waves are discretely determined at the N outputs of the photonic processor. The detection functionalities are enhanced by introducing some tracking functions implemented in a post-processing stage at the photonic unit output. The benefits and disadvantages of each tracking function are illustrated. Lastly, an approximation to reduce the photonic unit to a unitary one is discussed, rendering a compact device that operates only on a narrow detection range.

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CP1

Full Euler Equations for Waves Generated by Vertical Seabed Displacements

We present a novel numerical method for simulating the generation and propagation of surface gravity waves by vertical seabed displacements. The cornerstone of our method is the computation of a time dependent conformal map which incorporates the time dependent geometry of the seabed and the wave profile along the free surface. This enables us to handle general geometric configurations of the seabed and the wave. As benchmark we reproduce the results of Hammack on tsunami generation and propagation. Our results show that Hammack's linear theory accurately predicts wave generation. However, as the velocity of the sea bed displacement increases, nonlinear effects become increasingly noticeable. Notably, when the seabed uplift occurs rapidly, the following nonlinear dynamics of the wave differ significantly from the linear dynamics usually associated with tsunami propagation.

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CP2

New (2 + 1)-Dimensional Burgers Equation and Its Solitary Wave Solutions via the Lie Symmetry Method

In this paper, the new $(2+1)$-dimensional Burgers equation has been derived using the Burgers equation' recursion operator as follows

$$u_{xt} + (u_t + uu_x - \nu u_{xx})_y + 3\left(u_x \partial_x^{-1} u_y\right)_x = 0.$$

This nonlinear model is an interesting generalization of the Burgers equation. Because of its complexity, we have applied the Lie symmetry approach to an equivalent equation of the new Burgers equation to achieve 6-dimensional vector fields of symmetry. The reduction process under four symmetries subalgebras helps to investigate four simpler equations, one of which is the famous Riccati equation. Therefore, four explicit solutions are attained and graphically illustrated in 3D and contour plots. Different solitary wave dynamics of the new $(2+1)$-dimensional Burgers equation are determined, which includes bright soliton, breather, kink, periodic solution and some interactions.

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CP2

Modelling of Long Three-Dimensional Surface Gravity Waves

Two different classes of surface gravity waves can be found from the 2+1-dimensional cKdV-type equation depending upon whether the coefficients are evaluated using the general, or singular, solution of R.S. Johnson's generalised Burns condition. From the general solution, plane waves that propagate at an arbitrary angle to the parallel current are obtained. Conversely, with the singular solution (envelope of the general solution), ring waves propagating over such currents are obtained. We numerically study the stability of the line solitons to three-dimensional transverse perturbations in this regime within the scope of the 2+1-dimensional Green-Naghdi equations. We also model the propagation of hybrid waves consisting of an arc of a ring wave connected to plane waves. This is joint work with Dmitri Tseluiko, Sergey Tkachenko and Karima Khusnutdinova.

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CP2

PainleveBacklundCheck: A Sympy-Powered Kivy App for the Painlevé Property of Nonlinear Dispersive PDEs and Auto-Bäcklund Transformations

In the present work we revisit the Painlevé property for partial differential equations. We consider the PDE variant of the relevant algorithm on the basis of the fundamental work of Weiss, Tabor and Carnevale and explore a number of relevant examples. Subsequently, we present an implementation of the relevant algorithm in an open-source platform in Python and discuss the details of a Sympy-powered Kivy app that enables checking of the property and the derivation of associated auto-Bäcklund transform when the property is present. Examples of the relevant code and its implementation are also provided, as well as details of its open access for interested potential users.

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CP2

Inverse Scattering Transform for Continuous and

Discrete Space-Time Shifted Integrable Equations

Nonlocal integrable partial differential equations possessing a spatial or temporal reflection have constituted an active research area for the past decade. Recently, more general classes of these nonlocal equations have been proposed, wherein the nonlocality appears as a combination of a shift (by a real or a complex parameter) and a reflection. In this talk, we give an overview of the Inverse Scattering Transform for several examples of such systems; including space, time, and space-time shifted versions of the Nonlinear Schrödinger (NLS) equation and its Ablowitz-Ladik discretization.

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CP2

Asymptotic Behaviors of a Coupled System with Different Wave Speeds

We are concerned with a coupled system of second order evolution equations with different wave speeds and indirect memory-damping, where the damping only appears in one equation of the coupled system. With the help of the generalized positive definite kernel theory we recently presented, we study the asymptotic behaviors of the coupled system and obtain a polynomial stability result for the energy of the system with different wave speeds. Moreover, we give applications of the polynomial stability result to a class of Timoshenko systems with different wave speeds and some system of coupled Petrovsky type equations with different wave speeds.

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CP2

Stability of Doubly Periodic Patterns of the Focusing Nonlinear Schrdinger Equation

Doubly periodic solutions expressible in terms of the Jacobi elliptic functions are investigated for the nonlinear Schrdinger equation. Such solutions can be realized through doubly periodic patterns observed in experiments in fluid mechanics and optics. The stabilities of these doubly periodic wave profiles in the focusing regime are studied computationally by using two different approaches. Firstly, instability will occur if the eigenvalues of the monodromy matrix obtained from Floquet theory are of modulus larger than unity. This is verified by numerical simulations with input patterns of different periods. Initial patterns associated with larger eigenvalues will disintegrate faster due to stronger instability. Secondly, the formation of these doubly periodic patterns from a tranquil background is scrutinized. Doubly periodic profiles are generated by perturbing a continuous wave with one Fourier mode, with or without the additional presence of random noise. The predicted instability of these doubly periodic profiles is in excellent agreement with that derived from Floquet analysis. Acknowledgement: Partial financial support has been provided by the Research Grants Council General Research Fund project 17204722.

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CP3

Model Reduction for the Complex Ginzburg-Landau Equation Using Neural Networks and Curriculum-Based Learning

The complex Ginzburg-Landau equation is a nonlinear partial differential equation that models several types of natural phenomena in fluids, including coherent structures in the wake of a bluff body, and instabilities in a boundary layer. We consider reduced-order models of this equation in a parameter regime in which there is a stable periodic orbit with a 2-dimensional slow manifold. Our approach uses a novel type of neural-network architecture, which consists of a linear term that can be precomputed to improve the encoding, or reconstruction, of states at initialization. A 2-dimensional reduced-order model is constructed by applying this new architecture in two ways. First, an autoencoder neural network is used to learn the geometric description of the slow manifold in state space; the encoder is then reinitialized to learn the dynamics on the slow manifold. Second, a feedforward network is trained to correctly identify initial conditions in the latent space. The latter network achieves this objective by using backward time reduced-order model predictions as targets for the encoding of initial transients. Our approach outperforms standard neural network architectures, such as fully-connected autoencoders trained solely on reconstruction loss, in terms of prediction accuracy for a given model complexity.

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CP3

A Numerical Method for Granular Avalanche Flow on An Inclined Plane Using SavageHutter Equations

The Savage-Hutter (SH) equations are a hyperbolic system of nonlinear partial differential equations describing the temporal evolution of the depth and depth-averaged velocity for modeling the avalanche of a shallow layer of granular materials on an inclined plane. These equations admit the occurrence of shock waves and vacuum fronts while possessing the special reposing state of granular materials. In this paper, we propose a numerical scheme for the solution of the SH equations using the discontinuous Galerkin method. We adopt a TVD slope limiter to suppress numerical oscillations near discontinuities. Numerical results for the dry granular materials down an inclined plane under various internal, bed friction, and slope angles are given to show the performance of the numerical scheme.

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CP3

Path-Conservative Central Upwind Schemes for Weakly Compressible Two-Layer Shallow Water Flow

We formulate a model for two-layer shallow water with friction in channels of varying cross-sections, considering the weak compressibility of both layers. Employing the method of generalized Rankine-Hugoniot conditions [3], we derive the Riemann invariants for shock and contact waves. Additionally, we present a high-resolution, non-oscillatory semi-discrete path-consistent central-upwind scheme. The properties of the scheme, such as positivity and well-balance, are discussed. Alongside the scheme's description and proofs of these properties, we present several numerical experiments that demonstrate the robustness of the numerical algorithm. Furthermore, we validate the exact solution using the numerical approach. References [1] G. Hernandez-Duenas, J. Balbas, "A Central-Upwind Scheme for Two-layer Shallow-water Flows with Friction and Entrainment along Channels", ESAIM: Mathematical Modelling and Numerical Analysis, 55, pp. 21852210, 2021. [2] A. Chiapolino, R. Saurel "Models and methods for two-layer shallow water flows", Journal of Computational Physics, 371, pp. 1043-1066, 2018. [3] Dal Maso, G., Lefloch, P.G. and Murat, F., "Definition and weak stability of nonconservative products" Journal de Mathmatiques Pures et Appliques, 74(6), pp.483-548, 1995.

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CP3

Numerical Methods for the Nonlinear Schrödinger Equation with Low Regularity Potential and Nonlinearity

We establish error estimates for various numerical methods applied to the nonlinear Schrödinger equation (NLSE) with low regularity potential and nonlinearity, including purely bounded potential and locally Lipschitz nonlinearity. In many physical applications, low regularity potential and nonlinearity are introduced into the NLSE. Typical examples include the square-well potential or step potential, which are discontinuous, and the non-integer power nonlinearity (with logarithmic function) arising in the famous Lee-Huang-Yang correction of the mean-field energy. New analysis techniques are needed to establish error bounds on classical numerical methods, and novel accurate and efficient methods also need to be developed. Moreover, new spatial discretization method that can be efficiently coupled with corresponding temporal discretization is also required.

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CP3

Traveling and Dispersive Shock Wave in Granular Crystals and Related Chains

In this talk, we will focus on the so-called granular lattice dynamical system whose equations of motion can be represented by a system of discrete nonlinear ordinary differential equations. We consider a number of continuous approximations and regularizations thereof. For the resulting nonlinear PDEs, we investigate the existence of associated traveling solitary waves and periodic waves. The family of periodic waves motivates the interesting topic of the dispersive shock waves, which is intimately related to the so-called Whitham modulation theory. In the latter context, the so-called modulation equations serve as the key characterization which reveals the information about the associated dispersive shock wave of a given system. We will elaborate on the theory by particularly discussing the method to derive the system of modulation equations. Time permitting, we will consider a comparison of the relevant findings with direct numerical simulations.

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CP3

A Novel Parametrization of Arbitrary Complex Matrices for Photonic Realization of General Discrete Linear Transformations

Recent progress in the characterization and implementation of optical systems at the nanoscale regime has allowed the deployment of compact and energy-efficient optical circuits. Such photonic-enabled computing technologies have yielded a growing interest in designing and manufacturing architectures that perform specific mathematical operations based solely on the propagation properties of guided modes confined in the waveguides. Notably, the authors of [M. Reck et al., PRL **73**, 58 (1994)] introduced a novel mechanism to implement any arbitrary unitary operation solely using a lens setup. This has paved the way for more compact solutions using nanophotonic elements, such as MMIs, meshes of MZIs, and coupled waveguide arrays. This talk introduces a new proof-of-concept solution to perform arbitrary linear transformations based on interlaced unitary waveguide array layers with phase and amplitude modulation layers. The latter is implemented using phase-change material, permitting a π phase-modulation at the scale of 20 um. The present architecture is programmable and can perform general lossless and lossy vector-matrix multiplication, such as DFT and convolution. Numerical evidence shows the convergence of the proposed architecture when reconstructing arbitrary Haar random matrices. For completeness, the proposed devices are tested using wave propagation simulations to illustrate the feasibility of the present solution.

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CP4

High-Order Rogue Wave Formation in Bose-Einstein Condensates

We provide numerical evidence of high-order rogue wave formation in the focusing nonlinear Schrdinger equation from Thomas-Fermi-like initial conditions. The initial conditions are ground states of the defocusing Gross-Pitaevskii equation with a harmonic trap making the preparation of such waveforms feasible in an experimental setting. We confirm the persistence of rogue wave formation in higher dimensions through numerical studies of the non-polynomial Schrdinger equation and the full three-dimensional case.

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CP4

The Generation and Interaction of Solitary Waves under the Presence of Quartic Dispersion in Kerr Media

Solitons are self-reinforcing localized wave packets that have remarkable stability features that arise from the balanced competition of nonlinear and dispersive effects in the medium. Traditionally, the dominant order of dispersion has been the lowest (second), however in recent years, experimental and theoretical research has shown that high, even order dispersion may lead to novel applications. We focus on investigating the interplay of dominant quartic (fourth-order) dispersion and the self-phase modulation due to the nonlinear Kerr effect in laser systems. One big factor to consider for experimentalists working in laser systems is the effect of noise on the inputs to these systems. Therefore, we numerically analyze the generation of localized states arising from dominant quartic dispersion where noise is added on the inputs to the laser system and the resulting robustness of these states. In addition, we also examine the interaction of solitary waves with dominant quartic dispersion in different media and how these results can differ from the conventional case of dominant quadratic dispersion. The results show that the behavior that is exhibited for the quadratic case for generation of pulses is maintained and furthermore, there are increased opportunities for stable localized states in quartic Kerr media.

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CP4

Quantum Dark-Soliton in One-Dimensional Bose Gas

The mean-field approach in weakly interacting ultracold Bose gases leads to the Gross-Pitaevskii equation, also known as the nonlinear Schrdinger (NLS) equation. In the one-dimensional Bose particle gas described by the Lieb-Liniger model, the density profile of a specific quantum state closely matches that of the NLS soliton solutions under periodic boundary; such quantum states are called quantum dark soliton states. Through exact computational methods, we've constructed quantum dark soliton states with several exotic features: a quantum dark soliton state that is topologically wound [K. Kinjo, E. Kaminishi, T. Mori, J. Sato, R. Kanamoto, and T. Deguchi, Universe **8**, 2 (2022)] and a quantum dark soliton which has two notches [K. Kinjo, J. Sato and T. Deguchi, J. Phys. A: Math. Theor. **56**, 164001 (2023)].

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CP4

Beyond All Orders of the ”NLS” Description

We carry out the multiple-scale derivation of the NLS equation up to arbitrary order for a general class of wave equations. When the group and phase velocities are exponentially close to each other, we show that the soliton dynamics completely departs from what the NLS equation predicts. The shape of the fundamental soliton, whether bright or dark, remains as in the textbook picture. However, the motion is now governed by the exponentially weak interaction between the wave envelope and the carrier wave. This interplay results in a finite locking range in which the velocity of the wave packet is not constant but always oscillates around an average value. The average speed of the soliton is the phase velocity instead of the group velocity. We provide an intuitive reason for this phenomenon as well as an analysis based on Stokes phenomenon beyond all orders of the multiple-scale expansion. Eventually, a new equation of motion is derived in the vicinity of the locking range. In a frame that moves at the phase velocity, it turns out to be equivalent to that of a pendulum. The generality of the derivation suggests that the conclusions apply generically to weakly nonlinear wave packets in dispersive systems that admit equality of group and phase velocities at a certain wavelength.

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CP4

Array modes in superconducting quantum circuits and qubit design optimization

The Josephson junction (JJ) is arguably the most important building block of modern superconducting circuits. Large arrays of JJs have found applications in quantum information processing, quantum metrology, quantum-limited amplification, and many-body simulation. In superconducting quantum computing, serially-connected arrays of JJs are used to create so-called ”superinductors”. Along with single JJs and capacitors, superinductors form the contemporary toolbox of circuit elements from which superconducting qubits are constructed. The internal degrees of freedom of a superinductor are strongly coupled, forming higher-order ”array modes” of the circuit. When designing qubit circuits, one typically wishes to keep the frequency of these array modes much higher than the system temperature, such that they can be safely neglected when considering the circuit dynamics. However, accurately predicting the array mode frequencies requires solving the full Hamiltonian of the circuit, including the degrees of freedom associated with the many JJs of the superinductor. In this work we discuss an exactly solvable model for the array modes of fluxonium, a superconducting qubit formed by shunting a Josephson junction with an inductance formed by a one-dimensional array of junctions. The quantum mechanical behavior of fluxonium is described by circuit quantization; which yields a many-body Hamiltonian, involving a quantum variable for every junction in the circuit.

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CP5

Stability and Dynamics of Massive Vortices in Two-Component Bose-Einstein Condensates

We study vortex-bright solutions of the two dimensional two-component Gross-Pitaevskii equation with quadratic potential with particular focus in the regime where the mixed interaction coefficient is large. Various relevant properties of the stationary solutions are provided including the spectral stability, and we show dynamical properties of unstable structures that upon propagation in time eventually eject multiple vortex-bright structures. We also monitor the resulting dynamics after displacing the vortex-bright structure away from the origin giving flowering trajectories that demonstrate radial oscillations as well as precessional motion. In line with earlier works we map these dynamics to an appropriate particle model.

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CP5

Solitary and Periodic Traveling Waves for the Infinite Calogero-Moser Lattice

We study waves on an infinite one dimensional lattice of particles that each interact with all others through power-law force $F \sim r^{-3}$. This corresponds to Calogero-Moser systems which are well-known to be completely integrable for any finite number of particles. For the infinite particle case, we find explicit formulas that describe solitary and periodic traveling waves.

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CP5

Scattering of An Ostrovsky Wave Packet in a Coupled Waveguide

Detecting delamination in layered structures is crucial due to potential structural failure. Experiments on polycarbonate bars have detected delamination through changes in the transmitted wave field [1]. We will discuss the scattering of long longitudinal bulk strain waves in a two-layered waveguide, modelled by a system of coupled Boussinesq equations. The materials of the layers are similar, with a delamination sandwiched between soft bonding [2]. We employ direct numerical modelling and a semi-analytical approach, constructing a weakly-nonlinear solution [3]. In the soft bonded regions, Ostrovsky wave packets form, which evolve into a soliton and dispersive radiation in the delaminated region. There is excellent agreement between the two numerical schemes. Finally, we will analyse phase shifts in the final bonded region for various delamination lengths as understanding the wave behaviour can indicate delamination size even without prior knowledge of the delamination length is. [1] G.Dreiden, K.Khusnutdinova, A.Samsonov, et al. Bulk strain solitary waves in bonded layered polymeric bars with delamination. J. Appl. Phys. 112, 063516 (2012) [2] J.Tamber, D.Chappell, J.Poore, et al. Detecting delamination via nonlinear wave scattering in a bonded elastic bar. Nonlinear Dyn (2023). [3] J.Tamber and M.Tranter. Scattering of an Ostrovsky wave packet in a delaminated waveguide. Wave Motion, 114, 103023, 07 (2022).

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MS1

Discrete Optical Solitons

Discrete optical solitons represent a coherent state of light intensity realized in waveguide arrays. The first experimental realizations appeared around 35 years ago. In the well known case of nearest neighbor coupling of waveguides, the model that decribes propagation and coherent states is the well-known discrete nonlinear Schroedinger equation. This presentation will discuss theoretical advances when one extends the model to consider global coupling of waveguides in particular in a configutarion that in the long-wave (continuum limit) leads to a fractional spatial diffraction operator.

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MS1

Computation of Convective Laser-Fluid Flows

The computation of steady solutions to the Navier–Stokes equations is considered with internal, laser-driven forcing. Solutions are determined on a finite, two-dimensional domain with the Boussinesq approximation governing the natural convection flow response to the laser heating. Radial basis functions with finite difference are used to discretize derivatives over a domain of arbitrary geometry. The resultant steady flows are found to have strong dependence on domain size, with the domain shape having a smaller but non-negligible effect on the flow. Preliminary results are presented for coupling laser propagation with this new computational scheme for laser-driven convection.

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MS1

Wave Collapse in Water Waves and Analogies to Nonlinear Optics

In certain depth regimes and in certain ranges of wavelengths, both the capillary-gravity and flexural-gravity water-wave problems exhibit analogies to nonlinear optics behaviour in a Kerr medium. Both of their dynamics is described by a 2D focusing nonlinear Schrdinger equation (or equivalent), for the modulation of the carrier waves. The analogues to Townes solitons in optics are small amplitude and finite energy lump solitons in deep water. Contrary to the case in optics, the primitive equations (the Euler equations) can be more easily integrated and compared to the NLS behaviour, in particular exploring the nonlinear focussing collapse instability beyond the NLS regime.

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MS2

Phase-Shifted Nanopterons in a Model of KdV Coupled to An Oscillatory Field and Lattice Applications

We develop nanopteron solutions for a coupled system of singularly perturbed ordinary differential equations that is a local model of various nonlocal systems that govern different problems in Fermi-Pasta-Ulam-Tsingou (FPUT) lattices. To leading order, one equation governs the traveling wave profile for the Korteweg-de Vries (KdV) equation, while the other models a simple harmonic oscillator whose small mass is the problems natural small parameter. A nanopteron solution consists of the superposition of an exponentially localized term and a small-amplitude periodic term. We construct two families of nanopterons. In the first, the periodic amplitude is fixed to be exponentially small but nonzero, and an auxiliary phase shift is introduced in the periodic term to meet a hidden solvability condition lurking within the problem. In the second, the phase shift is fixed as a (more or less) arbitrary value, and now the periodic amplitude is selected to satisfy the solvability condition. These constructions adapt different techniques due to Beale and Lombardi for related systems. As an immediate application, we use the model problem to solve a system of coupled KdV-KdV equations and then sketch its generalization to some FPUT problems.

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MS2

Dispersive Shock Waves in Nonlinear Dynamical Lattices: a Few Select Examples

This work is motivated by the presence of a series of experiments in discrete (or effectively) discrete media in recent years that feature the emergence of dispersive shock waves. Our considerations are motivated by a prototypical FPUT-type system that arises in the realm of granular crystals and has been monitored experimentally. That prompted us to start from some dispersionless continuum reductions and to obtain some information from them, as well as to realize their limitations. Subsequently some dispersive regularizations at the continuum level in the context of the KdV and Boussinesq-type approximations are considered, as are discrete integrable approximations at the level of the Toda lattice. In some of these, such as KdV and Toda, Whitham modulation theory tools can be brought to bear to offer reasonable approximations of the original motivating (granular) problem in the presence of the so-called precompression. Finally, time permitting, a prototypical non-integrable first order in time lattice is considered, where a considerable additional wealth of dynamical phenomena (in addition to the standard dispersive shocks and rarefaction waves) can be observed. The latter appears to constitute a fertile basis for future explorations of discrete systems and their dispersive hydrodynamic behavior.

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MS2

A Rigorous Approximation of a Certain Random Fermi-Pasta-Ulam-Tsingou (FPUT) Lattice by the Korteweg-De Vries (KdV) Equation

We review recent results regarding the rigorous approximation of 1D and 2D disordered (random, independent masses and/or springs) harmonic lattices by effective wave equations in the long wave limit. In this linear setting, we show the homogenization argument and highlight the tools used from probability theory to control the stochastic error terms such as the Law of the Iterated Logarithm and Hoeffdings inequality. With our discussion of the linear problem serving as a springboard, we then present a new result regarding the approximation of an FPUT lattice with random masses by a KdV equation. Specifically, we are able to bound the approximation error in terms of the small parameter from the long wave scaling in an almost sure sense. In our theorem, we require a technical condition on the random masses, which we call transparency. Our proof relies on the incorporation of an auto-regressive process into an approximating ansatz, which itself is approximated by solutions to the KdV equation. We discuss the role of the auto-regressive process as well as the condition of transparency in the proof and give numerical evidence supporting the result. We conclude by discussing open questions such as the apparent lack of KdV dynamics in an FPUT lattice with independent, random masses.

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MS2

Supersonic Kinks and Solitary Waves

We consider a Fermi-Pasta-Ulam chain of masses connected by nonlinear springs in which a hardening response is taken over by a softening regime above a critical value of the deformation strain. We show that in addition to traveling pulses (solitary waves) this discrete Hamiltonian system also supports non-topological and dissipation-free fronts (kinks). Moreover, we argue that these two types of supersonic traveling wave solutions belong to the same family. Inside this family, tensile and compressive solitary waves have continuous velocity ranges which extend up to a limiting speed corresponding to a kink. As the kink limit is approached, the solitary waves become progressively broader and acquire the flat-top (flat-bottom) structure of a kink-antikink bundle. To support our study of the discrete problem we also analyze a quasicontinuum approximation with temporal dispersion which is shown to capture the main effects not only qualitatively but also quantitatively.

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MS3

Front Instabilities in a Reaction-Diffusion Model of Tumor Invasion

We consider planar traveling fronts representing tumor growth in a reaction-nonlinear-diffusion model of tumor invasion. While such fronts are typically stable in one spatial dimension, instabilities can appear in two spatial dimensions when viewing the front as planar interface. Using geometric singular perturbation methods, we describe how the structure of traveling fronts depends on critical system parameter which represents the effect of acid produced by tumor cells on healthy tissue. We also examine the effect on the stability of the resulting interface to perturbations in two spatial dimensions using a combination of asymptotic methods and numerical simulations.

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MS3

Resilience to Environmental Variability in a Flow-kick Model of Dryland Vegetation Pattern Formation

We explore the impact of variability in rain storm frequency and intensity on banded vegetation patterns in dryland ecosystems. These patterns often appear on gently sloped terrain as regularly spaced bands of vegetation alternating with bare soil. Our modeling framework treats storms as instantaneous kicks to the soil water, which then interacts with vegetation during the long dry periods between the storms. The spatial profiles of soil water kicks capture positive feedbacks in the storm-level hydrology that act to concentrate water within the vegetation bands. We use a combination of linear stability analysis and numerical simulation to study the resilience of the vegetation patterns as a function of changing storm characteristics when when randomness is introduced into the rainfall model.

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MS3

Travelling Waves Due to Negative Plant-Soil Feedbacks in a Model Including Tree Life-Stages

The emergence of tree species diversity in tropical forests is commonly attributed to the Janzen-Connell (JC) hypothesis, which states that growth of seedlings is suppressed in the proximity of conspecific adult trees. As a result, a JC distribution due to a density-dependent negative feedback emerges in the form of a transient pattern where conspecific seedling density is highest at intermediate distances away from parent trees. Several studies suggest that the required density-dependent feedbacks behind this pattern could result from interactions between trees and soil-borne pathogens. However, negative plant-soil feedback may involve additional mechanisms, e.g. the accumulation of autotoxic compounds due to tree litter decomposition. An essential task therefore consists in constructing mathematical models incorporating both effects showing the ability to support the emergence of JC distributions. In this talk, we investigate a novel reaction-diffusion-ODE model describing the interactions within tropical tree species across different life stages as driven by negative plant-soil feedback. We show that under strong negative plant-soil feedback travelling wave solutions exist, creating transient distributions in agreement with the JC hypothesis. Moreover, we show that these travelling wave solutions are pulled fronts, calculate their linear spreading speed and analyse its (in)dependence on relevant nondimensional parameters.

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MS3

Controlling Pattern Stability by Noninvasive Feedback

In several noteworthy biological applications, mathematical predictions of pattern formation in the models proposed by biologists are at odds with experimental and observational evidence. Predicted patterns do not arise, or theoretically unobservable patterns are nevertheless observed. However, the inclusion of additional biologically relevant feedback loops in the underlying model has a direct impact on both its analytical feasibility and its fundamental explanatory power. The framework of control theory provides a valuable perspective on addressing this discrepancy. We investigate the stabilisation of hitherto unstable patterns in singularly perturbed reaction-diffusion systems by an external control input, which can be interpreted as a pre-pattern or as the effective input of external processes that are not part of the model itself. We show that by extending the Evans function method previously used to determine the stability of far-from-equilibrium patterns, a wide range of spatio-temporal controls can be incorporated, and that their influence on the stability of a specific preselected pattern can be determined explicitly. We demonstrate this control method in the context of a toy model, where a singular pulse can be stabilised by a spatially localised control term. We discuss the interpretation of this control in a biological context. This is joint work with Isabelle Schneider, FU Berlin.

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MS4

Shifting Parties in Social Dynamics – a Nonlocal Approach

The bounded confidence model is well-known for its dynamics of party formation within the sphere of social dynamics. We investigate the addition of bias terms, modeling shifts in opinions, and the resulting dynamics including coherent movement of parties. We analyze this movement using a novel, nonlocal approach for the study of the resulting forward-backward delay equations. Different from existing methods, we compute Taylor expansions in function space. This approach leads to an algebraically simple computation of the reduced flow on a center manifold, allowing for proof of coherent small-amplitude movement.

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MS4

Modulational Instability of Small Amplitude Wave Trains in the Novikov Equation

We consider the Novikov equation, which models the propagation of unidirectional shallow water waves. It is similar to the Camassa-Holm or Degasperis-Procesi equation but with cubic nonlinearities. The Novikov equation has a family of periodic traveling waves that includes small perturbations of the constant state, so we analytically study the spectral stability of those waves. In particular, we obtain a result about the modulational stability and instability of said waves.

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MS4

Breathers in Theory and Reality

Fifty years ago, special, localized two-soliton bound state solutions of the sine-Gordon equation were called breathers because they incorporate two timescales: one associated with propagation and the other associated with internal oscillation. The term breather has since been generalized to solutions of other integrable equations with associated non-self adjoint scattering problems such as the modified Korteweg-de Vries equation and the focusing nonlinear Schrodinger equation. In this talk, the notion of a breather with two timescales is extended to soliton-cnoidal wave interaction solutions of the Korteweg-de Vries (KdV) equation, originally studied fifty years ago as ”solitary dislocations”. It is argued that breathers with nonvanishing oscillatory tails are more common than their localized brethren. They naturally arise as special solutions of integrable equations with associated self adjoint scattering problems and, importantly, as solutions of non-integrable equations. Both dark and bright breathers are presented as solutions of KdV and other integrable equations. They are used to interpret soliton-dispersive shock wave transmission and trapping as well as solitary wave-periodic traveling wave interaction experiments in a viscous core-annular flow.

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MS4

The Higher-order Nonlinear Schrdinger Equation on the Half-line

We establish local well-posedness in the sense of Hadamard for a certain third-order nonlinear Schrdinger equation with a multi-term linear part and a general power nonlinearity known as the higher-order nonlinear Schrdinger equation, formulated on the half-line with data in Sobolev spaces. We consider both high regularity and low regularity solutions. In the former setting, the relevant nonlinearity can be handled via the Banach algebra property; in the latter setting, however, this is no longer the case and, instead, Strichartz estimates must be established. This task is particularly interesting in the framework of nonhomogeneous initial-boundary value problems, as it involves proving boundary-type Strichartz estimates that are not common in the study of Cauchy (initial value) problems. The linear analysis, which forms the core of this work, crucially relies on a weak solution formulation defined through the unified transform of Fokas. In this connection, we note that the higher-order Schrdinger equation comes with an increased level of difficulty due to the presence of more than one spatial derivatives in the linear part of the equation. This feature manifests itself in various ways throughout the analysis, including analyticity issues related to complex square roots and complicated oscillatory kernels in the weak solution formulation.

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MS5

The Phase Space of the Three-Vortex Problem

The motion of three point-vortices in a 2D inviscid, incompressible fluid has been widely studied. Grbli (1877) derived a closed system for the evolution of the side lengths of the triangle formed by the vortices. This system has been the basis of most studies of this problem. These coordinates have a few disadvantages. First, the coordinates must satisfy the triangle inequality, so not all points in $\mathbb{R}^3$ are physical. Second, the system introduced nonphysical singularities because collinear arrangements lie on the boundary of the triangle inequality. Third, these coordinates break the useful Hamiltonian structure and make phase-plane reasoning difficult. We introduce a coordinate system for this problem that overcomes these disadvantages using a sequence of systematic and standard reductions. We first use Jacobi coordinates, a common technique in n-body systems, and further apply a Nambu Bracket reduction. The method avoids creating non-physical singularities and makes the system's phase-space geometry and topology plain. A previous Nambu-bracket formulation based on Grbli's reduction inherited its triangle-inequality-related disadvantages. Depending on the circulations, the phase space may be a sphere or one sheet of a two-sheeted hyperboloid. Prior attempts to classify the dynamics focused solely on the stability of the relative fixed points; this approach allows us to explain the results more clearly using the entire phase space.

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MS5

A New Computational Approach to Investigate the Dynamics of Rotating Superfluids

The equilibrium state of a superfluid in a rotating cylindrical vessel is a vortex crystal – a relative equilibrium which is also the global minimizer of the free energy. We present a new computational method to chart the free energy landscape around the global minimizer using gradient-based optimisation of a scalar loss function. The loss functions employed, which are used to find new simple invariant sets, are based on entire solution trajectories, and efficient optimisation is enabled with our fully differentiable solver ‘jax-pv. We converge thousands of low-free-energy relative equilibria in the unbounded domain for small numbers of vortex lines, from which we discover previously unknown continuous families of relative equilibria. These families are often global minimizers of the free energy, and all consist of crystals arranged in a double-ring configuration. We assess which state from the family is most likely to be observed experimentally by computing energy-minimising pathways from nearby local minima. We adapt our approach to compute homoclinic orbits and examine the dynamics in the vicinity of the minimising state by converging connections for low-energy saddles. Time permitting, we will explore a recent hypothesis that vortex dipoles are as important as individual vortex cores to the dynamics of two-dimensional turbulence (Jimnez, Journal of Turbulence 21, 2020), by using jax-pv to find relevant simple invariant solutions from point-vortex dynamics.

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MS5

Dipole Scattering Dynamics Within the Point Vor-

tex Model

In this talk, we will discuss the close analogy of the point vortex model to the two-dimensional nonlinear Schrdinger equation in the limit of well-separated sub-sonic vortices. Using this analogy, we investigate the stability and scattering dynamics of point-vortex dipoles via interaction with a variety of different vortex cluster configurations. We compare these results to similar quantum vortex states modelled using the nonlinear Schrdinger equation.

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MS5

Dynamics of Vortex Ring Arrays

The interaction of coaxial thin-cored vortex rings forms a Hamiltonian dynamical system when the thickness of the rings remains small compared to their radii. For instance, two thin coaxial vortex rings exhibit a rich array of dynamics including the well-known phenomenon of 'leapfrogging', in which two vortex rings successively pass through each other while they propagate in the same direction along their common axis. In this talk, I will explore the interaction of N periodic arrays of thin-cored vortex rings, which can also be shown to be a low-order Hamiltonian dynamical system possessing the same number of integrals in involution as the non-periodic case. In particular, the motion of two periodic arrays of vortex rings – the periodic 2-vortex ring problem – is integrable and can be examined using a phase plane analysis over a periodic domain. The dynamical system will be parameterized using the impulse P, the relative strength of the two arrays of vortex rings, γ, and the relative thickness of the vortex rings β. Vortex ring 'crystals' in a periodic domain — arrangements in which a number of vortex rings remain stationary relative to each other — will also be explored.

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MS6

Hamiltonian Floquet Theory

We consider the stability problem obtained by linearizing a Hamiltonian dispersive PDE about a periodic traveling wave solution. We show that the Hamiltonian symmetry induces a symmetry in the corresponding monodromy matrix that is more general than infinitesimal symplecticity, as it relates the monodromy at $-\lambda$ to the the mondromy at λ. We show that for a d-dimensional problem one can explicitly find a figure in $\mathbb{R}^{d-1}$ such that a necessary and sufficient condition for λ to have maximal spectral multiplicity is that the Floquet discriminant lies in a certain compact open set in $\mathbb{R}^{d-1}$. For instance for $d = 3$ (KdV, etc) this domain is the interior of the Steiner curve. This is a natural generalization of the fact that in two dimensions a necessary and sufficient that λ lie in the spectrum is that the Floquet discriminant lies in the interval $[-2, 2]$. We also define a bifurcation discriminant, which identifies points on the imaginary axis from which the curves of essential spectrum can bifurcate. In dimensions $d \leq 3$ the vanishing of the bifurcation discriminant is a necessary and (modulo some genericity conditions) sufficient condition for the occurrence of a bifurcation. For $d > 3$ it is necessary but not sufficient.

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MS6

Characterizing Buoyant Flow Instabilities for Wind-Driven Fires

Many phenomena of interest in the wildland fire community can be understood through the lens of pattern formation in the underlying system of nonlinear PDEs. To explore one such phenomenon, we consider a reaction-diffusion model of combustion that admits traveling wave solutions. The stability properties of these solutions are sensitive to changes in the form of the wind term responsible for convective heat transfer. Analysis of the corresponding eigenvalue problems using a Sturm-Liouville framework reveals a range of parameters corresponding to wind intensity and smoothness for which we may expect to see pattern formation. We verify our analytic results through numerical simulations using a finite difference method.

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MS6

Computation of Indices for Stability of Nonlinear Waves

The stability of waves often hinges on solving eigenvalue problems derived from linearizing equations around their respective steady states. While the term "solving" doesn't entail explicitly determining these eigenvalues, obtaining insightful information about them aids in addressing stability concerns. In this talk, we will explore computational and analytical tools demonstrating a convenient method to counting eigenvalues represented by an angle fluctuating within the phase space of the eigenvalue problem. We will use a cubic nonlinear Schrdinger equation with a decaying potential to illustrate our approach. It then becomes critical to count the eigenstates in the gap on the imaginary axis beneath the essential spectrum, highlighting the need to identify a comparable angular variation within the appropriate phase space. We illustrate how this concept is realized by employing an extension of Sturm-Liouville theory based on the Maslov Index.

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MS6

On the Stability of Smooth Solutions to Peakon Equations

The Camassa-Holm equation with linear dispersion was originally derived as an asymptotic equation in shallow water wave theory. Among its many interesting mathematical properties, perhaps the most striking is the fact that it admits weak multi-soliton solutions - peakons- with a peaked shape corresponding to a discontinuous first derivative. Since the discovery of the Camassa-Holm equation, several peakon equations with similar properties, both in the integrable and non-integrable cases have been studied. Among them, there is the integrable Novikov equation, which can be regarded as a generalization to a cubic nonlinearity of the Camassa-Holm equation. Furthermore, both the Camassa-Holm and the Novikov equations each admit a generalization taking the form of a one-parameter family of peakon equations, most of which are not integrable. In this talk, we study the spectral and orbital stability of various smooth solutions to peakon equations. One of the main difficulties when dealing with the linear operators arising from peakon equation is that they often include a non-local term. An additional challenge is the fact that the localized smooth solutions admit a nonzero background.

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MS7

Nonlinear Dynamics and Coherent Laser Frequency Microcombs at the Thermodynamical Limits

Dissipative Kerr soliton microcombs in microresonators have enabled fundamental advances in chip-scale precision metrology, communication, spectroscopy, and parallel signal processing. We describe advances in the coherent structures and nonlinear dynamics of laser frequency microcombs in dispersion-engineered microresonators. Firstly, we report the generation of self-stabilized soliton microcombs in strongly-coupled dual-polarization microresonators, accessing rich soliton dynamics, sub-100-fs pulse generation, and good 1/f 2 single-sideband phase noise performance. Secondly, resonant power switching dynamics are observed with pump wavelength forward and backward detuning. Distinct power transients facilitate resonant power buildup and kick out, leading to the formation of dissipative solitons at blue detuning. The pump laser settles in the thermal-locking regime which fundamentally mitigates the characteristic thermal destabilization during soliton formation and results in good phase noise of our optical-to-microwave oscillator. Thirdly, deterministic soliton nonlinear transitions are observed, with distinct soliton formation routes via cross-phase interaction and from the chaotic or periodic waveforms. Fourthly, soliton temporal evolution portraits are recorded with a parametric time magnifier with picosecond temporal resolution, MHz frame rate and sub-ns temporal window. This platform offers unique capabilities in metrology, sensing, imaging and communications.

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MS7

Advances on the Nonlinear and Stochastic Dynamics of Microcombs

In this communication, we discuss some of the latest advances in the field of microresonator optical frequency comb generation. These oscillators are expected to play a major role in several areas of photonic technology owing to their outstanding metrological performances. We discuss here some of the latest advances related to the understanding of nonlinear and stochastic phenomena in these dissipative spatially extended systems.

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MS7

Two-Point Self-Injection Locked Microcomb Oscillators

Kerr frequency combs can be produced in a nonlinear cavity pumped with coherent light of high enough power. Free running Kerr frequency combs demonstrate outstanding spectral purity of their repetition rates being decoupled from the fluctuations of the coherent optical pump. However, the noise of the individual optical harmonics of the combs follows the fluctuations of the pump light and can be high. Stabilizing one or two harmonics of the comb may result in the improvement of its characteristics. In this presentation we report on the study of fluctuations and drifts of the Kerr comb parameters, discuss various ways of the comb stabilization, and show that the self-injection locking is one of the most powerful techniques for obtaining ultra-low noise Kerr comb-based devices.

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MS7

Multi-Frequency Combs and Dissipative Solitonic Waves in Two-Dimensional Microcavities

Optical frequency comb forming platforms are mostly based on one-dimensional temporal pulses. In particular, the most robust combs exhibiting both wide spectrum and minimized frequency jitter are realized in microring resonators by means of ultra-short temporal dissipative solitons. In our recent works, we started exploring the novel physical phenomena and unique degrees of freedom that spatiotemporal two-dimensional solitons bring to optical microcombs. So far, we predominantly addressed such solitons in the most natural two-dimensional extension of microring resonators, namely the cylindrical microresonators. In this geometry, light is confined to the cylinders surface and it is free to diffract along the cylinders axis, hence the light dynamics is restricted to two-dimensions. In this minisymposium we review our results, emphasising the dynamical aspects with no one-dimensional analogues. In the elliptic regime of the microcylinder (anomalous dispersion), we first discuss the formation of two-dimensional soliton clusters arising due to the spatially anisotropic intersoliton forces associated to the dispersive conical waves. In addition, we uncover a mechanism by which perfectly periodic soliton trains may undergo self-replications, leading to identical synchronised copies of themselves. In the hyperbolic regime (normal dispersion), we discuss the recently discovered photonic snakes, robust zigzagging waveforms leading to heterogeneous two-dimensional combs.

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MS8

Waves in peridynamical media

Peridynamics decribes the interactions in a spatially extended Hamiltonian systems by nonlinear integro-differential equations which can be regarded as a generalisation of both lattice and PDE models. In this talk we prove the existence of periodic traveling waves in a variational setting and discuss a natural condition for the existence of solitary limits. We also discuss the numerical computation of waves as well as two asymptotic regimes related to small and large energies.

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MS8

Darboux's Theorem, Lie Series and the Standardization of the Salerno and Ablowitz-Ladik Models

In the framework of nonlinear Hamiltonian lattices, we revisit the proof of Moser-Darboux's Theorem, in order to present a general scheme for its constructive applicability to Hamiltonian models with non-standard symplectic structures. We take as a guiding example the Salerno and Ablowitz-Ladik (AL) models: we justify the form of a well-known change of coordinates which is adapted to the Gauge symmetry, by showing that it comes out in a natural way within the general strategy outlined in the proof. Moreover, the full or truncated Lie-series technique in the extended phase-space is used to transform the Salerno model, at leading orders in the Darboux coordinates: thus the dNLS Hamiltonian turns out to be a normal form of the Salerno and AL models; as a byproduct we also get estimates of the dynamics of these models by means of dNLS one. We also stress that, once it is cast into the perturbative approach, the method allows to deal with the cases where the explicit trasformation is not known, or even worse it is not writable in terms of elementary functions.

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MS8

Long Waves and Solitons in Lattices with Power-law Forces

We study motions of one-dimensional particle lattices with all-to-all interactions given by forces that decay as the p-th power of distance. The case $p = 3$ corresponds to Calogero-Moser systems, well-known to be integrable for finitely many particles. For $1 < p < 4$, small-amplitude, uni-directional waves are found to be governed formally by a nonlocal dispersive PDE that reduces to the Benjamin-Ono equation for $p = 3$. One obtains the KdV equation if $p \geq 4$ or the forces alternate in sign. Moreover, we find explicit formulas for periodic waves and solitons in the infinite Calogero-Moser lattice.

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MS8

Propagation Reversal for Bistable Differential Equations on Trees

In this talk we study travelling wave solutions to bistable differential equations on infinite k-ary trees. These graphs generalize the notion of classical square infinite lattices and our results complement those for bistable lattice equations on $\mathbb{Z}$. Using comparison principles and explicit lower and upper solutions, we show that wave-solutions are pinned for small diffusion parameters. Upon increasing the diffusion, the wave starts to travel with non-zero speed, in a direction that depends on the detuning parameter. However, once the diffusion is sufficiently strong, the wave propagates in a single direction up the tree irrespective of the detuning parameter. In particular, our results imply that changes to the diffusion parameter can lead to a reversal of the propagation direction.

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MS9

The Role of Boundary Constraints in Simulating Biological Systems with Nonlocal Dispersal

Mathematical and numerical studies of pattern forming systems often use reaction-diffusion equations as models. However, when considering biological phenomena, a nonlocal form of flux, or equivalently diffusion, often provides a better description of the transport processes that are involved. This is the case of vegetation and population models, where the spread of plant seeds and individuals is better represented by a convolution operator. While the resulting integro-differential equations are able to better model these systems, they are often difficult to simulate. In particular, one needs to provide information about the unknown variable outside the computational domain as an additional constraint. In this talk we explore if and how different types of boundary constraints affect the shape of patterns using the Gray Scott model as a motivating example.

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MS9

The Space Between Us: Modeling Spatial Heterogeneity in Synthetic Microbial Consortia Dynamics

A central endeavor in bioengineering concerns the construction of multistrain microbial consortia with desired properties. Typically, a gene network is partitioned between strains, and strains communicate via quorum sensing, allowing for complex behaviors. Yet a fundamental question of how emergent spatiotemporal patterning in multistrain microbial consortia affects consortial dynamics is not understood well. In this talk, we will describe a computationally tractable and straightforward modeling framework that explicitly allows linking spatiotemporal patterning to consortial dynamics. We validate our model against previously published results and make predictions of how spatial heterogeneity impacts interstrain communication. By enabling the investigation of spatial patterns effects on microbial dynamics, our modeling framework informs experimentalists, helps advance the understanding of complex microbial systems, and supports the development of applications involving them.

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MS9

Patterns of Minimal Surfaces in Endoskeletons

Three-dimensional patterns, including fcc and bcc lattices and three-periodic minimal surfaces occur in natural structures such as endoskeletons of sea creatures. These structures form through processes involving nucleation and growth, and one observes variation in material properties throughout the structures. We analyze these patterns using a nucleation-and-growth model and a Legedre-hodograph approach to analyzing the surfaces.

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MS9

A Gut Feeling: Developing a Model of Mouse Colon Motility Through Data

Colon motility, the spontaneous self-generated movement and motion of the colon muscle and its cells, is produced by activity in different types of cells such as myenteric neurons of the enteric nervous system (ENS), neurons of the autonomic nervous system (ANS) and interstitial cells of Cajal (ICC). Two colon motor patterns measured experimentally are motor complexes (MC) often associated with the propulsion of fecal contents, and ripple contractions which are involved in mixing and absorption. How ICC and neurons of the ENS and ANS interact to initiate and influence colon motility is still not completely understood. This makes it difficult to develop new therapies to restore function in pathological conditions. This talk will discuss the data-driven modeling of the ICCs and neurons that also capture the global dynamics that are observed in the colon.

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MS10

Discontinuous Galerkin Methods for the Numerical Solution of Cahn-Hilliard Type Models

Cahn-Hilliard type models are presented. For their numerical solution Discontinuous Galerkin Finite Element (DG-FE) schemes are developed and analyzed. Simulations that verify the theoretical results are shown.

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MS10

Dynamical Reduction for Coherent Structures: A Quasi-particle Approach for Vortices, Vortex Rings, and Solitonic Filaments

In this talk we describe techniques for the dynamical reduction of localized structures (such as solitons, kinks, filaments, vortices, and vortex rings) in nonlinear spatio-temporal systems. The central idea is to cast reductions to accurately describe these structures with lower-dimensional models that are more easily tackled, both mathematically and computationally. In turn, the reduced models allow for an unprecedented description of the statics, stability, dynamics, and interactions of these structures.

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MS10

Quantum Droplet Correlated Phases of Matter and Their Dynamics

We will discuss the formation of quantum droplet phases of matter arising in two-component bosonic mixtures. Insights regarding the interplay of atom and interaction imbalance as well as the impact of dimensionality are provided. These phases are analyzed within the extended Gross-Pitaevskii framework and an ab-initio many-body non-perturbative method which allows to identify beyond Lee-Huang-Yang correlations. A simplified effective model based on the established Lee-Huang-Yang theory is constructed and found to provide qualitative analytical predictions. For instance, it is explicated that for moderate particle imbalance each component maintains its droplet flat-top or Gaussian type character depending on the intercomponent attraction. Interestingly, an increasing intercomponent imbalance leads to a flat-top shape of the majority component with the minority exhibiting spatially localized configurations. The latter imprint modulations on the majority component which become more pronounced for increasing interspecies attraction. These structural transitions are also evident in the respective two-body correlation functions. Generalizations to Bose-Fermi mixtures will be also discussed.

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MS10

Recent Developments in the Spectral Theory of Soliton Gases: Soliton and Breather Gases of Focusing Systems of AKNS type

A one-parameter family of finite-band elliptic potentials for a non-self-adjoint Dirac operator is studied in the semiclassical limit, together with the corresponding finite-genus solutions of the focusing nonlinear Schrödinger and modified Korteweg-de Vries equations. These potentials also produce a family of finite-band PT-symmetric potentials for Hill's equation with purely real spectrum. Two distinguished limits yield constant background and sech-shaped potentials. Importantly it is shown that these potentials provide a realization of a deterministic breather gas, which transitions to a soliton gas as a special limit.

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MS11

Approach and Separation of Bundles of Quantized Vorticity

In the quasi-classical regime of quantum turbulence, it has long been hypothesised that there exists coherent vortical structures, made up of bundles of quantised vortices. More recently, there has been significant experimental evidence that points to their presence. Here, we perform the first quantitative study of the reconnection of bundles of quantised vorticity and show that the approach and separation of bundles during a reconnection is consistent with the symmetric $\delta \sim t^{1/2}$ scaling which is consistent with studies of individual quantised vortex reconnection and classical vortex reconnections. We also examined the phenomena of 'bridge' structures that form between the vortex bundles during the reconnection process and have also been observed during the reconnection of classical vortices. We study their persistence and suggest that their dissipation is driven by vortex-vortex interactions within the bridge itself.

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MS11

Topological Constraints on the Dynamics of Vortex Formation in a Two-Dimensional Quantum Fluid

We present experimental and theoretical results on the generation of quantum vortices in a laser beam propagating in a nonlinear medium. In addition to the conservation of vorticity, another topological constraint imposes a complex dynamical behavior to the formation and annihilation of vortex/anti-vortex pairs. We identify two such mechanisms, both described by the same fold-Hopf bifurcation. One of them has been first proposed more than 30 years ago but had not been observed experimentally so far. The other one is new and appears particularly efficient. These results suggest new (experimentally relevant) observables for studying the transition to turbulence.

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MS11

The N-vortex Problem in Doubly-periodic Domains with Background Vorticity

We study the N-vortex problem in a doubly periodic rectangular domain in the presence of a background vorticity field. We first consider a constant background field and derive an explicit formula for the hydrodynamic Green's function using a conformal mapping approach. We show that the point vortices form a Hamiltonian system and that the two-vortex problem is integrable. Several fixed lattice configurations are obtained for general N, some of which consist of vortices with inhomogeneous strengths and lattice defects. We then consider a smooth background field given by the Liouville PDE and show example solutions in which point vortices exist in stationary equilibrium with the background.

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MS11

Time-Dependent Spanwise Variations in Membrane Flutter Dynamics

Extensible membranes are soft materials that undergo significant stretching in a fluid flow. Examples include textile fabric, rubber, or the skin of swimming and flying animals. We study rectangular membranes with deflections that have significant spanwise nonuniformity and that shed a trailing vortex-sheet wake when immersed in a 3-D inviscid fluid flow. We determine how these spanwise variations in membrane deflection depend on various material and geometric parameters. We use both a spanwise-symmetric and spanwise-asymmetric initial perturbation and find that the motions differ for long times but eventually reach the same steady state in most cases. At large times, we find interesting spanwise symmetric and asymmetric oscillations, with the latter more common. With the membrane's side-edges free, traveling waves along the span frequently exist but oscillations in the form of side-to-side and other standing wave motions along the span, also occur.

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MS12

Nonlinear Rayleigh-Taylor Instability of the Viscous Surface Waves in An Infinitely Deep Ocean

In this paper, we consider an incompressible viscous fluid in an infinitely deep ocean, being bounded above by a free moving boundary. The governing equations are the gravity-driven incompressible Navier-Stokes equations with variable density and no surface tension is taken into account on the free surface. After using the Lagrangian transformation, we write the main equations in a perturbed form in a fixed domain. In the first part, we describe a spectral analysis of the linearized equations around a hydrostatic equilibrium $(\rho_0(x_3), 0, P_0(x_3))$ for a smooth increasing density profile ρ_0. Precisely, we prove that there exist multiple normal modes to the linearized equations by following the operator method initiated by Lafitte and Nguyen [Spectral analysis of the incompressible viscous Rayleigh-Taylor system in $\mathbb{R}^3$, Water Waves]. In the second part, we study the nonlinear Rayleigh-Taylor instability around the above profile by constructing a wide class of initial data for the nonlinear perturbation problem departing from the equilibrium, based on the finding of multiple normal modes. Our nonlinear result follows the previous framework of Guo and Strauss [Instability of periodic BGK equilibria, Comm. Pure Appl. Math.] and also of Grenier [On the nonlinear instability of Euler and Prandtl equations, Comm. Pure Appl. Math.] with a refinement.

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MS12

Downshifting Without Dissipation: The Dynamics of Water Waves Near the Benjamin-Feir Instability

he Benjamin-Feir (BF) instability is one of the most famous instabilities within water waves, referring to the disintegration process that a uniform wave undergoes in water that exceed $kh_0 \approx 1.363$. Despite six decades since its discovery there are aspects of its dynamics have remained elusive, including the ability of waves to restabilize at later stages of the instability with increased amplitude and a downshift in the spectral peak. Widely believed to be an exclusively dissipative process, recent studies present numerical evidence suggesting that this downshifting may occur without dissipation. Can we theoretically substantiate the possibility of downshifting without energy loss? This talk presents a theoretical framework that confirms that downshifting may occur without dissipative effects. Via modulation theory we derive a nonlinear PDE that governs the evolution of the wavenumber for surface waves, which degenerates at the BF transition due to a simultaneous collision of eigenvalues and a local linear degeneracy. When resolved via rescaling the system admits a novel dispersive PDE that supports heteroclinic connections between wavenumbers, suggesting downshifting is possible. We provide numerical evidence that validates how waves at the BF threshold exhibit downshifting in the absence of viscosity and demonstrate that the downshifted wave exhibits reduced energy density to shed light on the underlying mechanisms responsible for wave restabilization.

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MS12

Multidimensional Stability and Transverse Bifurcation of Hydraulic Shocks and Roll Waves in Open Channel Flow

We study by a combination of analytical and numerical methods multidimensional stability and transverse bifurcation of planar hydraulic shock and roll wave solutions of the inviscid Saint Venant equations for inclined shallow-water flow, both in the whole space and in a channel of finite width, obtaining complete stability diagrams across the full parameter range of existence. Technical advances include development of efficient multi-d Evans solvers, low- and high-frequency asymptotics, explicit/semi-explicit computation of stability boundaries, and rigorous treatment of channel flow with wall-type physical boundary. Notable behavioral phenomena are a novel essential transverse bifurcation of hydraulic shocks to invading planar periodic roll-wave or doubly-transverse periodic herringbone patterns, with associated metastable behavior driven by mixed roll- and herringbone-type waves initiating from localized perturbation of an unstable constant state; and Floquet-type transverse “flapping’ bifurcation of roll wave patterns.

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MS13

Multi-Color Broad-Bandwidth Solitons in Microresonators

The recent discovery that it is possible to achieve metrological coherence over a broad bandwidth in a microresonator [G. Moille et al., Nature **624**, 267 (2023)] was enabled by using two pumps. A primary pump generates a soliton. A narrow-band reference pump at a lower frequency then captures a soliton comb tooth, creating a broadband soliton. A dispersive wave at a higher frequency that is nearly twice the lower frequency makes it possible to lock down the entire comb. Here, we present a qualitative analysis whose aim is to illuminate the basic length and time scales that govern the soliton dynamics in this microresonator and others that are similar. Comb generation is a stroboscopic process in which a single soliton is sampled once every round trip, generating a series of pulses in an output waveguide. A mismatch between the (angular) phase and group velocities leads to a phase slip every round trip. With two pumps, there can be two group velocities and two phase velocities. There are then three regimes of operation: (i) When the group velocity offset is too large to be compensated by the nonlinear interaction, two different combs with two different comb spacings are observed. (ii) When the nonlinearity is sufficiently strong to lock the group velocities, but not strong enough to lock the phase velocities, then two or three interleaved combs are observed. (iii) When the nonlinearity can also lock the phase velocities, then a broadband comb is observed.

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MS13

Synchronization Regimes of Multi-Pumped Integrated Octave Spanning Frequency Comb

Integrated frequency combs hold promise for portable metrology technology, enabling accurate timekeeping, distance ranging, and low noise microwave generation [1]. Smaller cavities, beyond obvious reduction of the footprint, require fewer comb teeth for octave-spanning self-stabilization and reduce pump power, enabling battery operation [2]. Recent progress in silicon nitride fabrication allows for mass-scale production of these small cavities [3], like microring resonators. Despise all these advantages, small cavity soliton microcombs present high repetition rates (in the terahertz), making the stabilization and the control of the repetition rate challenging. Here we present a new technique coined Kerr induced synchronization (KIS), where a reference laser injected in the cavity soliton microring captures one of its comb teeth [4]. This enables external control of the microcomb metrics, namely its repetition rate and carrier envelop offset (CEO). We will present how this new effect can be harnessed in the scope of integrated optical clocks, improving both the CEO detection and repetition rate locking to the atomic element. We will also discuss new effects that can be harnessed with this new technique by drawing parallels with other physical systems following the same type of (Adler) equation. [1] S. Diddams et al Science 369, 6501 (2020) [2] B. Stern et al Nature 562, 7727 (2018) [3] J. Liu et al Nat Com 12, 1 (2021) [4] G. Moille et al Nature 624, 7991 (2023)

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MS13

Dissipative Localized States in Nonlinear Microresonators: a Bifurcation Study

It is already well known that the generation of frequency combs in microresonators is closely related to the emergence of dissipative structures (DSs) of different types and morphologies. In this regard, most of my research focuses on understanding the dynamical behavior of frequency combs through their underlying DSs. Particularly interesting are DSs which are localized in time such as the so-called temporal cavity solitons. These states generally form through the locking of front waves connecting two coexisting states and can be understood from generic universal mechanisms. In this context, I have characterized, by applying dynamical systems and bifurcation theory, the formation of localized DSs in the presence of quadratic and cubic nonlinearities. By doing so, I have performed a classification of these different states, their dynamics and stability as a function of the control parameters of the system. Remarkably, despite nonlinearities of different types, I have found similarities between the localized states arising in different cavity configurations. These studies provide stability roadmaps which may pave the way to efficient experimental protocols for localized states and frequency comb generation.

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MS14

The instabilities of Stokes waves

The different instabilities to which traveling surface water waves of permanent form (the so-called Stokes waves) are susceptible, has been a topic of much interest, this past decade. In fact, it is fair to say that the stability problem for small-amplitude Stokes waves is now well understood, numerically, asymptotically, and analytically. I will present an overview of the advances made this past decade.

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MS14

Solitary Water Waves on Graphs

We have deduced a weakly nonlinear, weakly dispersive Boussinesq system for water waves on a 1D branching channel, namely on a graph. The reduced model requires a compatibility condition at the graphs node, where the main reach bifurcates into two reaches. Our new nonlinear compatibility condition arises from a stationary shock condition and generalizes that found in Stoker (1957), used since then. Our numerical method uses the Schwarz-Christoffel (conformal) mapping in order to generate a boundary fitted coordinate system for the forked channel region. This allows for general branching angles. We present numerical simulations comparing solitary waves on the 1D graph model with results of the (parent) 2D model, where a compatibility condition is not needed. It is shown that the condition given in Stoker is of limited accuracy. As time permits, further modeling developments will be presented.

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MS14

Verification of the Wave Turbulence Theory through Stereo-imaging Techniques

When the number of interacting waves is large enough, a deterministic description of the wave field becomes unfeasible and, just like for a gas of particles, a statistical description is needed. Such theoretical task was achieved by V. Zakharov who, in the late sixties, developed the Wave Turbulence Theory which allows to find stationary and out of equilibrium states, known as the Kolmogorv-Zakharov spectra. Nowadays, using stereo-imaging technique, it is possible to measure the sea-surface elevation both in time and space. Such measurements represent a perfect tool for establishing the validity of the Wave Turbulence Theory for ocean waves. In the talk I will present a data set measured from the Acqua Alta Oceanographic Tower place about 15 km from the coast of Venice and I will discuss the results in terms of the Wave Turbulence Theory.

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MS14

A Hamiltonian Approach to Nonlinear Modulation of Surface Water Waves in the Presence of Vorticity

This is study of the water wave problem in a two-dimensional domain of infinite depth in the presence of nonzero constant vorticity. A goal is to describe the effects of uniform shear flow on the modulation of weakly nonlinear quasi-monochromatic surface gravity waves. Starting from the Hamiltonian formulation of this problem (Wahlén 2007, Constantin-Ivanov-Prodanov 2008), and using techniques from Hamiltonian transformation theory, we derive a Hamiltonian Dysthe (high order nonlinear Schrödinger) equation for the time evolution of the wave envelope. Consistent with previous studies, we observe that the uniform shear flow tends to enhance or weaken the modulational instability of Stokes waves depending on its direction and strength. Our method also provides a non-perturbative procedure to reconstruct the surface elevation from the wave envelope, based on the Birkhoff normal form transformation to eliminate all non-resonant triads. This model is tested against direct numerical simulations of the full Euler equations and against a related Dysthe equation recently derived by Curtis, Carter and Kalisch (2018). This is a joint work wth P. Guyenne and A. Kairzhan.

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MS15

Soft Matter Quasicrystals in Higher Dimensions: Spatial Localisation, Reduced Symmetries and Defects

Soft matter systems self-assemble into a wide range of spatial patterns (including quasipatterns) as asymptotic states during crystallisation. Using a phase field crystal approach, this can be modelled as a pattern forming PDE system that is governed by a conserved dynamics. Traditional first tools for analysis of such pattern forming systems include linear stability analysis, weakly nonlinear analysis, direct simulations and numerical continuation. In this work, we explore the additional use of computational algebraic geometry and topological data analysis to explore and characterise respectively, the multitude of invariant solutions that exist in higher dimensions. In addition to periodic approximants of quasipatterns, we also focus on spatial localisation of quasipatterns, quasipatterns with reduced symmetries and those with included defects, both in two and three dimensions.

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MS15

On the Group of Almost Periodic Diffeomorphisms and Its Applications

We define a group of almost periodic diffeomorphisms of the Euclidean space. We then study its properties and provide applications to several equations appearing in fluid dynamics.

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MS15

Long-Time Nonlinear Quasi-Periodic Dynamics of Perturbed Traveling and Standing Water Waves

We present a unified method of computing the spectral stability of traveling and standing water waves to harmonic or subharmonic perturbations. We explore the long-time dynamics of these perturbations as they grow in amplitude beyond the realm of linear theory, which we find can lead to Fermi-Pasta-Ulam recurrence. To track the growth of subharmonic perturbations, we develop a framework to compute and study fully nonlinear spatially quasi-periodic water waves, which are represented as periodic functions on a higher-dimensional torus evaluated along irrational directions.

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MS15

Spatially Quasi-Periodic Water Waves of Finite Depth

We present a framework for computing and studying two-dimensional spatially quasi-periodic gravity-capillary water waves of finite depth. Specifically, we adopt a conformal mapping formulation of the water wave equation and represent quasi-periodic water waves by periodic functions on a higher-dimensional torus. We will present numerical examples of traveling quasi-periodic water waves and the time evolution of water waves over quasi-periodic bathymetry. If time permits, we will discuss an approach to extend this study to three dimensions.

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MS16

abcd-Boussinesq Model: Control and Stability Results

The *abcd*-Boussinesq system is a model of two equations that describes the propagation of small-amplitude long waves in both directions in the water of finite depth. In the last years, the mathematical community has shown interest in this model, so, in this talk, we will give a brief historical overview of the main results regarding the control theory and stability (orbital and spectral) for this model.

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MS16

Norm Inflation for Generalizations of Novikov's Equation in the Critical Space

We consider generalizations of Novikov's equations (NE) that admit multipeakon solutions. This equation has been shown to be well-posed in Sobolev spaces H^s when $s > 3/2$, and ill-posed in the sense of norm-inflation and non-uniqueness, depending on the parameters present in the equation, when $s < 3/2$. We examine the boundary case $s = 3/2$ and show how norm-inflation arises with some modifications applied to the peakon-antipeakon construction used in the $s < 3/2$ construction.

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MS16

On Properties of Solutions to the Intermediate Long Wave Equation

In this lecture I will present results regarding the asymptotic behavior of solutions to the initial value problem associated with the Intermediate Long Wave (ILW) equation. We use recent techniques in order to show that solutions of this system decay to zero in the energy space in an appropriate domain. The result is independent of the integrability of the equation involved and it does not require any size assumptions. We also consider the asymptotic behavior of the solution in a domain moving in time in the right direction. This is a joint work in collaboration with G. Ponce (UCSB)

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MS16

On the Uniqueness of the Ground State Solution of the Cubic Nls with Inverse Square Potential and Its Applications

In this paper, we prove the existence and uniqueness of the ground state solution for NLS with inverse square potential and power nonlinearity for all $0 < p < 4$ and dimension $d \geq 3$ based on the adapted "shooting method". With this result and the thorough spectral analysis on the linearized operator, we construct the stable/unstable manifolds of the standing wave solution and classify solutions on the mass-energy level surface of the ground state in dimension $d = 3, 4, 5$. This is the joint work with K. Yang and C. Zeng.

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MS17

Spectral Stability, the Maslov Index, and Higher-

Order Crossing Forms: a Cautionary Tale

The Maslov index is a tool that has been used recently in a variety of contexts to determine the spectral stability of stationary solutions to evolutionary PDEs. Often one important feature of such results is a monotonicity result related to the crossing form, which allows one to effectively count the contributions to the index. When the crossing form is degenerate, the monotonicity proof may require a higher-order crossing form and become more delicate. This is the case, for example, in the Swift-Hohenberg equation. In this talk, we discuss a subtlety that arises with higher-order crossing forms. It is notable that this subtlety appears to be present, though unnoticed, in existing published results.

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MS17

The Maslov Index and the Spectral Stability Problem for Standing Waves of the Nonlinear Schrdinger Equation on An Interval

We use the Maslov index to study the spectrum of a class of linear Hamiltonian differential operators. We provide a lower bound on the number of positive real eigenvalues, which includes a contribution to the Maslov index from a non-regular crossing. A close study of the eigenvalue curves, which represent the evolution of the eigenvalues as the domain is shrunk or expanded, yields formulas for their concavity at the non-regular crossing in terms of the corresponding Jordan chains. This enables the computation of the Maslov index at such a crossing via a homotopy argument. We apply our theory to study the spectral (in)stability of standing waves in the nonlinear Schrödinger equation on a compact interval. We derive stability results in the spirit of the Jones–Grillakis instability theorem and the Vakhitov–Kolokolov criterion, both originally formulated on the real line.

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MS17

Stability of Waves Arising in Systems of Dispersive Equations

Stability of waves for scalar dispersive equations have been subject of many recent research papers. We explore some recent results on the existence and stability of waves, arising in such systems. In particular, we construct and analyze standing waves in the KdV-NLS system and the NLS system of the third harmonic generation.

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MS17

Well-Posedness, Stability, and Bifurcation for Keller-Segel Models on Compact Graphs

In this talk, we will discuss the Keller-Segel model describing chemotaxis processes on thin networks. The system of PDEs in question is a pair of reaction-advection-diffusion equations of parabolic and elliptic type. The first part of the talk concerns well-posedness of this system on arbitrary compact metric graphs. In the second part of the talk, we will focus on asymptotic stability, instability, and bifurcation of constant steady state solutions of the parabolic-parabolic and parabolic-elliptic chemotaxis models.

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MS18

Existence Theory for Spatially Quasiperiodic Solutions to Benjamin-Ono Equation

A common assumption in the study of the water waves problem and the related model equations is that solutions either decay or are periodic. Less explored, however, is what happens if we replace these assumptions with quasiperiodicity in space. In other words, what happens to solutions if initial data is a sum of periodic functions with non-commensurate periods? We discuss some recent results in this direction, namely in the case of the Benjamin-Ono equation and existence of its quasi-periodic solutions.

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MS18

Structural Implication of Constant Vorticity to Three-Dimensional Internal Waves

It is known that in many physical regimes, water waves beneath vacuum that have constant vorticity are necessarily two dimensional. The situation is more subtle for internal waves that traveling along the interface between two immiscible fluids. When the layers have the same density, there is a large class of explicit steady waves with constant vorticity that are three-dimensional in that the velocity field is pointing in one horizontal direction while the interface is an arbitrary function of the other horizontal variable. We prove that every three-dimensional traveling internal wave with bounded velocity for which the vorticities in the upper and lower layers are nonzero, constant, and parallel must belong to this family. If the densities in each layer are distinct, then in fact the flow is fully two dimensional. This is a joint work with Lili Fan, Samuel Walsh, and Miles Wheeler.

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MS18

Solitary Waves for Dispersive Equations with Coifman-Meyer Nonlinearities

In this talk, we present an existence result for solitary waves in a class of nonlinear, dispersive evolution equations with Coifman-Meyer nonlinearities. Much effort has been put into answering whether there are solitary-wave solutions to a class of unidirectional, nonlinear wave equations, $\partial_t u + \partial_x (Lu + n(u)) = 0$, which arise in the study of water waves. Here, L is a possibly nonlocal, linear Fourier operator, whereas n is a local, nonlinear function. While this is justified in many models, including the classical KdV and Boussinesq models, more exact modeling may produce terms with nonlinear frequency interaction. We therefore extend the theory to allow for nonlocal nonlinearities $N(u, u)$ in the form of pseudo-products or Coifman-Meyer Fourier operators. We establish the existence of smooth solitary waves to such equations when the linear multiplier is of positive and slightly higher order than the Coifman-Meyer nonlinear operator. The proof is based on a modified version of Weinsteins argument for L^2-constrained minimization using Lions method of concentration-compactness.

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MS18

Symmetric Doubly Periodic Gravity-Capillary Waves with Small Vorticity

Earlier efforts for rotational three-dimensional water waves have focused on the case of a Beltrami velocity field U. That is, where curl U is colinear with U. Inspired by an approach used by Lortz (1970) in the context of magnetohydrostatics, we construct small symmetric doubly-periodic gravity-capillary waves with a non-Beltrami velocity field. This is joint work with E. Wahln and D. S. Seth.

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MS19

Tight-Binding Models in Electromagnetic Systems

Topological insulators are characterized by topologically protected edges modes that are remarkably robust to lattice defects and perturbations. A popular approach to modeling them is that of tight-binding models. Two tight-binding models will be discussed in the context of Chern insulator photonic lattices. The first is a magneto-optical lattice, the second is a Floquet driven system. While the physical setup of these systems differ, the underlying tight-binding models (in appropriate regimes) are equivalent. Namely, both can be described by a Haldane-type models, suggesting the universal nature of the well-known equation.

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MS19

Data-Driven Approximation of Topological Insulator Systems

Electromagnetic wave propagation in a waveguide can be described by the one-dimensional time independent Schrodinger equation, which, in the deep lattice limit, can be sufficiently approximated by an SSH type model through constant coefficients interaction terms. A numerical program has been developed to compute the interaction coefficients based on user input potential or spectral band data. A nonlinear least squares approximation method (Levenberg-Marquardt) is utilized to minimize an objective function. The discrete models generated by the algorithm are capable of reproducing the expected physical and topological properties of a given system.

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MS19

Switching via Wave Interaction in Topological Lattices

A honeycomb Floquet lattice with helically rotating waveguides and an interface separating two counter-propagating subdomains is analyzed. Two topologically protected localized waves propagate unidirectionally along the interface. Switching can occur when these interface modes reach the edge of the lattice and the light splits into waves traveling in two opposite directions. The incoming mode, traveling along the interface, can be adjusted and routed entirely or partially along either lattice edge with the switching direction based on a suitable mixing of the interface modes.

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MS19

Edge States in Super Honeycomb Structures with PT Symmetric Deformations

The existence of edge states is one of the most vital properties of topological insulators. Although tremendous success has been accomplished in describing and explaining edge states associated with PT symmetry breaking, little work has been done on PT symmetry preserving cases. Two-dimensional Schrodinger operators with super honeycomb lattice potentials always have double Dirac cones at the G point the zero momentum point on their energy bands due to C6 symmetry, PT symmetry, and the folding symmetry caused by an additional translation symmetry. There are two topologically different ways to deform such a system by PT symmetry preserving but folding symmetry breaking perturbations. Interestingly, there exist two gapped edge states on the interface between such two kinds of perturbed materials. In this paper, we illustrate the existence of such PT preserving edge states rigorously for the first time. We use a domain wall modulated Schrodinger operator to model the phenomenon under small perturbations and rigorously prove the existence of two gapped edge states. We also provide a brief interpretation from the point of view of topology by the parities of degenerate bulk modes. Our work thoroughly explains the existence of helical like edge states in super honeycomb configurations and lays a foundation for the descriptions of topologies of such systems.

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MS20

Dispersive Hydrodynamics in a Quantum Droplet Bearing System

We study dispersive hydrodynamic phenomena in quantum droplets of homonuclear cold bosonic mixtures emerging from competing mean-field interactions and quantum fluctuations. The physical scenario in one-dimension is described by an extended Gross-Pitaevskii (GP) equation featuring an additional attractive, quadratic nonlinearity (Lee-Huang-Yang correction). Such a dual quadratic-cubic GP model supports various self-confined features such as droplets and bubbles, besides other coherent structures such as kinks. The mutual interactions of these coherent structures was recently examined and the formation of dispersive shock waves was identified as a consequence from various interaction scenarios. Inspired by this, we study the dispersive regularization of hydrodynamic singularities in such systems, by examining the wave-patterns that emerge after a long time from families of Riemann problems. The associated three-parameter family of Riemann problems displays a characterization that draws from the competition between the attractive and repulsive terms in the mean-field GP equation. We classify and characterize the emergent wave-patterns using a combination of direct numerical simulation and Whitham modulation theory. This is a collaborative effort with Prof. Simeon Mistakidis, Prof. Garyfallia Katsimiga and Prof. Panayotis Kevrekidis.

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MS20

Long-time Behavior of a Generalized Soliton Gas

I will discuss a class of ”generalized soliton gas” solutions to the modified Korteweg de Vries (mKdV) equation. I'll show how these solutions can be realized as the limit of a sequence of solutions of mKdV with N-solitons on a dispersive background (i.e., the potentials have non-zero reflection). This construction is general and can be applied to many other integrable PDEs (NLS, KdV, etc.) I'll then describe the large-time limit of these generalized soliton gas potentials to the mKdV equation.

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MS20

Diffraction and Interaction of Interfacial Solitons in a Two-layer Fluid of Great Depth

We present a novel isotropic bi-directional model for the study of weakly dispersive and weakly nonlinear atmospheric internal waves in a three-dimensional system consisting of two superimposed, incompressible, and inviscid fluids. The newly developed equation is the Benjamin-Benney-Luke (BBL) equation, a generalization of the famous two-dimensional Benjamin-Ono (2DBO) equation and the Benney-Luke equation, derived using the nonlocal Ablowitz-Fokas-Musslimani formulation of water waves. The evolution results of the BBL and 2DBO equations, performed by implementing the classic fourth-order Runge-Kutta method, the pseudo-spectral scheme with the integrating factor method, and the windowing scheme, show that the anisotropic 2DBO equation agrees well with the isotropic BBL model for problems being investigated, namely the focus is the central part of the soliton evolution/interaction zone. By applying the Whitham modulation theory, modulation equations for the 2DBO equation are obtained for analyzing the soliton dynamics in different initial-value problems. In addition, corresponding numerical results are obtained and shown to agree well with the theoretical predictions. Both theoretical and numerical results reveal the formation conditions of the Mach expansion, as well as the specific relationship between the amplitude of the Mach stem and the initial data.

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MS20

The Generalized Riemann Problem for the KortewegDe Vries Equation

The Riemann problem, considering an initial configuration of a discontinuous, step-like jump between two constant values, is a fundamental problem in dispersive hydrodynamics. This work extends the Riemann problem to address interactions between two periodic traveling waves, termed the Generalized Riemann problem, for the KortewegDe Vries equation. The examination starts with special classes of two-phase wave interactions consisting of two cnoidal wave solutions subject to a rapid transition in one wave parameter. Numerical simulations are performed for six distinct initial data cases, yielding the long-term emergence of two-phase bright/dark breather dispersive shock waves (BBDSWs/DBDSWs) characterized by a bright/dark breather train edge and a harmonic edge, as well as one-phase rarefaction wave-like structures with internal oscillations. The characteristic velocities of the waves are compared with predictions from multiphase Whitham modulation theory. These six special cases serve as building blocks for the comprehensive characterization of the Generalized Riemann problem. The findings of breather DSWs from two-phase wave interactions establish new avenues for future experimental observations and physical applications.

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MS21

Generation and Evolution of Singularities in Hydrodynamic Models of Wave Propagation

Interesting phenomena in fluid dynamics, both from a mathematical and a physical perspective, stem from the interplay between fluids and their boundaries. Singularities can form in finite time when material surfaces are in smooth contact with boundaries of a fluid under gravity, and, conversely, certain regularity can be regained in the course of the evolution. These effects can be analytically and numerically predicted by simple mathematical models and observed in simple experimental setups.

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MS21

Wave Turbulence, Weak and Strong

I will describe an attempt to describe wave turbulence using the methods of quantum field theory. We consider waves that interact via four-wave scattering (such as sea waves, plasma waves, spin waves, and many others). By taking into account multi-wave interactions, we obtain corrections to the wave kinetic equation, describing frequency and vertex renormalization. By analyzing the divergences in the perturbation theory, we show that the true dimensionless coupling is different from the naive estimate and find that the effective interaction either decays or grows explosively with the cascade extent, depending on the sign of the new coupling. The explosive growth possibly signals the appearance of a multi-wave bound state (solitons, shocks, cusps) similar to confinement in quantum chromodynamics. We find that IR divergence in the effective coupling could be responsible for an anomalous scaling in wave turbulence.

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MS21

Machine Learning and Inverse Scattering Transform: Data Recovery in Optical Fiber

The inverse scattering transform method was developed in the second half of the last century to solve a special class of equations with strong nonlinearity. It was shown that a certain operator is associated with such equations, the spectral data of which evolves linearly if the solution of the original equation was chosen as the potential for the spectral problem. Thus, the nonlinear dynamics of the equation was determined by the linear evolution of the corresponding spectral data. In this case, the procedure for solving the original nonlinear equation is to reconstruct the potential from the spectral data. The solution to this inverse problem was carried out either using the Gelfand-Levitan-Marchenko equations or the Reimann problem technique. We have shown that the recovery of a special class of potentials from spectral data can be carried out using machine learning. This approach is demonstrated using the example of data recovery after transmission in optical fiber operating in nonlinear regime.

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MS21

Lump Chains in the KP-I Equation

The Kadomstev–Petviashvili equation is one of the fundamental equations in the theory of integrable systems. The KP equation comes in two physically distinct forms: KP-I and KP-II. The KP-I equation has a large family of rational solutions known as lumps. A single lump is a spatially localized soliton, and lumps can scatter on one another or form bound states. The KP-II equation does not have any spatially localized solutions, but has a rich family of line soliton solutions that form evolving polygonal patterns. I will discuss two new families of solutions of the KP-I equation, obtained using the Grammian form of the tau-function. The first is the family of lump chain solutions. A single lump chain consists of a linear arrangement of lumps, similar to a line soliton of KP-II. More generally, lump chains can form evolving polygonal arrangements whose structure closely resembles that of the line soliton solutions of KP-II. I will also show how lump chains and line solitons may absorb, emit, and reabsorb individual lumps.

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MS22

Zero-Dispersion Asymptotics for Benjamin-Ono Soliton Ensembles

The Benjamin-Ono equation is, loosely speaking, a model for waves along the interface of two immiscible fluids. We discuss a recent attempt at the derivation of zero dispersion asymptotics for Benjamin-Ono soliton ensembles. A new explicit solution of the Benjamin-Ono equation was recently discovered by P. Gerard. We mention the consequences of this formula when applied to rational initial data in the zero dispersion limit.

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MS22

Yang-Baxter Maps Associated with Factorization Problems on Rational Loop Groups, and Their Poisson Geometry

This talk is about soliton collisions in multi-component soliton equations and the mathematics which grows out in its study. We will use the n-Manakov system (a.k.a. vector NLS) as our primary example. In this case, it is known that when two 1-solitons collide, the map which describes the change in polarizations is a (parametric) Yang-Baxter map, which is related to a special factorization problem on an associated rational loop group $K_{\rm rat}$. An open question in this example is whether the change in polarization map is a symplectic map. Motivated by this simple example, we show how to construct Yang-Baxter maps on a variety of geometric objects, based on factorization problems on $K_{\rm rat}$. Moreover, we also study the symplectic and Poisson geometry of these Yang-Baxter maps, which we show to be integrable maps in the sense of having natural Poisson commuting integrals. In a special case, the factorization problems we consider are associated with the N-soliton collision process in the n-Manakov system, and in this context we show that the polarization scattering map is a symplectomorphism. Finally, if time permits, we will indicate how such results can be used as the starting point to understand so-called reflection maps, which arise in soliton-boundary interactions.

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MS22

The Small-Dispersion Limit of the Intermediate Long Wave Equation

The Intermediate Long Wave (ILW) equation is an integrable nonlinear evolution equation which arises as an asymptotic (long-wavelength, small-amplitude) model for internal gravitational waves between two fluid layers, one shallow and the other of depth $\delta > 0$. In the limits of $\delta \to 0$ and $\delta \to \infty$, the ILW equation formally reduces to the Korteweg-de Vries equation and the Benjamin-Ono equation, respectively. For both of these limiting equations, the small dispersion limit for "bell-shaped" initial data has been studied rigorously using their respective Inverse Scattering Transforms (IST), while the problem remains open for the ILW equation. In this talk, we will review the formal IST for the ILW equation, introduce a modified asymptotic spectral data for a given "bell-shaped" initial data u_0 and prove weak convergence at time $t = 0$ of the solution associated to this modified spectral data to u_0.

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MS22

Large-Time Asymptotics of Solutions to the KP I Equation by the Method of Inverse Scattering

We obtain large-time asymptotics for solutions of the KP I equation

$$(u_t + u_{xxx} + 6uu_x)_x = 3u_{yy}$$

with small initial data using inverse scattering methods. Our results are motivated by previous work of Manakov, Santini, and Takhtajan and involve the solution of a nonlocal Riemann-Hilbert problem in two dimensions.

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MS23

On the Mass-Critical and Mass-Supercritical Inhomogeneous Nls Equation

We consider the inhomogeneous nonlinear Schrödinger (INLS) equation

$$iu_t + \Delta u + |x|^{-b}|u|^{2\sigma}u = 0, \ \ x \in \mathbb{R}^N,$$

with $N \geq 1$ and $b \in (0, \min\{N/2, 2\})$. The above model is a generalization of the classical nonlinear Schrödinger equation (NLS), obtained when $b = 0$. We focus on the mass-critical and mass-supercritical cases, where the scaling invariant Sobolev index $s_c = \frac{N}{2} - \frac{2-b}{2\sigma}$ satisfies $s_c \in [0, 1)$. In this talk we discuss well-posedness, scattering and blow-up results for the INLS equation in the radial and non-radial settings. These results were obtained in collaboration with Luccas Campos (UFMG-Brazil), Mykael Cardoso (UFPI-Brazil), Simão Correia (IST-Portugal), Carlos Guzmán (UFF-Brazil) and Jason Murphy (Missouri S&T-USA). This work is partially supported by CNPq, CAPES and FAPEMIG-Brazil.

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MS23

Special Properties of Solutions for the Benjamin-Bona-Mahony Equation

This work is concerned with the Benjamin-Bona-Mahony equation. This model was deduced as an approximation to the Korteweg-de Vries equation in the description of the unidirectional propagation of long waves. Our goal here is to study unique continuation and regularity properties on solutions to the associated initial value problem and intial periodic boundary value problems.

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MS23

Stability and Blow-up of Solitary Waves in Benjamin-Ono-type Equations

We consider the Benjamin-Ono (BO) equation and its generalizations in one and two dimensions and discuss stability of solitary waves in various settings. In particular, we discuss the 1d mBO and 2d HBO equations and examine stability of solitary waves vs. instability and blow-up.

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MS23

The Well-Posedness of a mKdV System on the Half-Line

The initial-boundary value problem (ibvp) for a coupled system of modified Korteweg-de Vries (mKdV) equations depending on a parameter α is studied on the half-line. It is shown that this system is well-posed for initial data $(u_0, v_0)(x)$ in spatial Sobolev spaces $H^s(0,\infty) \times H^s(0,\infty)$, $s > 1/4$, and boundary data $(g_0, h_0)(t)$ in the temporal Sobolev spaces suggested by the time regularity of the Cauchy problem for the corresponding linear problem. First, linear estimates in Bourgain spaces $X^{s,b}$ for $0 < b < 1/2$ are derived by utilizing the Fokas solution formula of the ibvp for the forced linear system. Then, using these and the needed trilinear estimates in $X^{s,b}$ spaces, it is shown that the iteration map defined by the Fokas solution formula is a contraction in an appropriate solution space. Finally, via a counterexample to trilinear estimates,the criticality of $s = 1/4$ for well-posedness is established. This is joint work wilt Alex Himonas.

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MS24

Stability of a Front in a Multi-Scale Diffusive Predator-Prey Model

Abstract: We consider a diffusive Rosenzweig - MacArthur predator-prey model in the situation when the prey diffuses at the rate much smaller than that of the predator. The existence of fronts in the system is known. The underlying dynamical system in a singular limit is reduced to a scalar Fisher-KPP equation and the fronts supported by the full system are small perturbations of the Fisher-KPP fronts. The current project is focused on the stability of the fronts. In particular, it is of interest whether the stability of the fronts is also governed by the scalar Fisher-KPP equation. The techniques of the analysis include a construction of unstable augmented bundles and their treatment as multi-scale topological structures.

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MS24

Generalized Maslov-Type Stability Indices

For a steady state of a nonlinear PDE, its stability is generally captured by a count of the unstable eigenvalues. The Evans Function and Maslov Index offer two approaches that are each appropriate for determining this index in certain types of problem. They both encode information from the geometry of the underlying state and the associated eigenvalue equations, but the Maslov Index is more stringent in its requirements of the underlying PDE. I will discuss ways in which the Maslov Index approach has been pushed in recent years to cover more complex problems than those for which it was originally intended.

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MS24

Some Geometrical and Dynamical Implications of the Topology of the Symplectic Group Sl(2,R)

I will outline briefly several examples of dynamical and geometrical phenomena where the topology of the symplectic group $SL(2,\mathbb{R})$ plays a central role.

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MS24

On the Spectral Instability of Some Cnoidal and Snoidal Waves of the Full Klein-Gordon-Zakharov System

The full Klein-Gordon-Zakharov system is considered in the space periodic context. We construct cnoidal and snoidal type solutions for the fast scale component. It is shown that in parts of the range, the waves are spectrally unstable with respect to co-periodic perturbations. The result relies on an instability index count for Hamiltonian systems, with self-adjoint portion consisting of a non-standard matrix Hill operator. The spectral analysis of these objects, and in particular the Morse index calculations, is a largely unexplored subject. The method we develop might prove useful for other systems or second order in time models.

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MS25
On a New Construction of Solitary Waves

Starting with the periodic waves earlier constructed for the gravity Whitham equation

$$u_t+(Lu+u^2)_x=0, \qquad \mathcal{F}(Lu)(\xi)=\left(\frac{tanh(\xi)}{\xi}\right)^{1/2}\mathcal{F}u(\xi),$$

we parametrize the solution curves through relative wave height, and use a limiting argument to obtain a full family of solitary waves. The resulting branch starts from the zero solution, traverses unique points in the wave speed-wave height space, and reaches a singular highest wave. The construction is based on uniform estimates on periodic waves together with limiting arguments and a Galilean transform to exclude vanishing waves and waves leveling off at negative surface depth. This work is joint with M. Ehrnstrm and C. Walker.

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MS25
Existence and Decay of Lump Solutions of the Fractional Kp Equation

The KadomtsevPetviashvili equation (KP equation) is a model equation that can be used to describe three-dimensional mainly unidirectional long waves of small amplitude. In this talk I will consider the fractional KadomtsevPetviashvili equation (fKP equation), which is a generalization of the classical KP equation involving a fractional derivative. As inte the case of the classical KP-equation, the fKP equation comes in two versions: fKP-I (strong surface tension) and fKP-II (weak surface tension). In the talk I will outline how to prove existence of lump solutions (travelling wave solutions which decay to zero in all horizontal directions) for the fKP-I equation. I will also discuss the smoothness and decay of these lump solutions. This talk is based on a joint work with Handan Borluk (Ozyegin University) and Gabriele Brll (Lund University).

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MS25
On Water Wave Borne Vortices

In this talk, we present some recent results on traveling gravity solitary waves water waves carrying vortices in their bulk. Our main result states that, for any supercritical Froude number (non-dimensionalized wave speed), there exists a continuous one-parameter family of solitary waves with a submerged point vortex in equilibrium. This family bifurcates from an irrotational laminar flow, and it extends up to the development of a surface singularity. These are the first rigorously constructed gravity wave-borne point vortices without surface tension, and notably our formulation allows the free surface to be overhanging. We further prove that at a generic member of this family — including waves that are large amplitude or even overhanging — the point vortex can be desingularized to obtain a solitary wave with a submerged hollow vortex. Physically, these can be thought of as traveling waves carrying spinning bubbles of air. This is joint work with Ming Chen, Kristoffer Varholm, and Miles H. Wheeler

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MS25
Overhanging Solitary Water Waves

Perhaps the most singular gravity waves with constant vorticity that have been observed numerically consist of a disk-like region of fluid in nearly rigid rotation which is connected to a horizontal strip by a narrow neck. In an ongoing collaboration, we rigorously construct such waves using desingularization techniques similar to those used for constant mean curvature surfaces. One of the main ingredients is an explicit model for the flow in the neck region.

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MS26
Topologically Protected Modes in Dispersive and Damped Materials

This work extends the theory of topological protection to dispersive and damped systems. This theory has emerged from the field of topological insulators and has been established for continuum models in both classical and quantum settings. It predicts the existence of localised interface modes based on associated topological indices and shows that, when such modes exist, they benefit from enhanced robustness with respect to imperfections. This makes topologically protected modes an ideal starting point for building wave guiding devices. However, in many practical applications such as optics or locally resonant metastructures, materials are dispersive in the operating frequency range or have damping in their permittivity function. In this case, the associated spectral theory is less straightforward. This work shows how the existing theory of topological protection can be extended to these settings. We consider time-harmonic waves in one-dimensional systems, at first with no damping, and then with damping.

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MS26

The Bifurcation of Dirac Points in Photonic/phononic Structures

The developments of topological insulators have provided a new avenue of creating interface modes (or edge modes) in photonic/phononic structures. Such created modes have a distinct property of being topologically protected and are stable with respect to perturbations in certain classes. In this talk, we will first review mathematical results on the existence of interface modes, and then report recent results on the creation of a in-gap interface mode that is bifurcated from a Dirac point in various two-dimensional photonic/phononic structures.

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MS26

Nonlinear Topological Valley Hall Edge States Arising From Type-II Dirac Cones

A Dirac point is a linear band crossing point originally used to describe unusual transport properties of materials like graphene. In recent years, there has been a surge of exploration of type-II Dirac/Weyl points using various engineered platforms including photonic crystals, waveguide arrays, metasurfaces, magnetized plasma and polariton micropillars, aiming toward relativistic quantum emulation and understanding of exotic topological phenomena. Such endeavors, however, have focused mainly on linear topological states in real or synthetic Dirac/Weyl materials. We propose and demonstrate nonlinear valley Hall edge (VHE) states in laser written anisotropic photonic lattices hosting innately the type-II Dirac points. These self-trapped VHE states, manifested as topological gap quasi-solitons that can move along a domain wall unidirectionally without changing their profiles, are independent of external magnetic fields or complex longitudinal modulations, and thus are superior in comparison with previously reported topological edge solitons. Our finding may provide a route for understanding nonlinear phenomena in systems with type-II Dirac points that violate the Lorentz invariance and may bring about possibilities for subsequent technological development in light field manipulation and photonic devices.

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MS26

Edge Spectrum of Topological Insulator with Curved Interface

Topological insulators (TIs) are 2D materials that act as insulators within their bulk while demonstrating robust states along their edges. One anticipated key properties of TIs is the robustness of this characteristics in relation to changes in the shape of their edges. This talk will explore the influence of edge shape on the properties of TIs. Specifically, we will offer a general, intuitive condition for this property to hold, along with a counterexample demonstrating its absence. Additionally, we will present a quantitative version of this property with a potential physical interpretation.

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MS27

Initial Value Problems for the Kadomtsev-Petviashvili Equation with Wedge-Shaped Step-Like Initial Conditions

In a recent work, the Whitham modulation equations for the Kadomtsev-Petviashvili (KP) equation (an integrable two-dimensional generalization of the KdV equation) were formulated. Some properties of the KP-Whitham modulation system were then subsequently studied, and its solitonic reduction was used to study suitable time evolution problems for the KP equation. In this work we perform a comprehensive set of numerical simulations to study the dynamics of solutions of the KP equation with wedge-shaped step-like initial conditions, and we show how the KP-Whitham system can be used to study the resulting novel phenomena associated with two-dimensional wave breaking.

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MS27

Whitham Modulation Theory in 2+1 Dimension: Two Case Studies

This presentation introduces Whitham modulation theory applied to two partial differential equations (PDEs): the Zakharov-Kuznetsov equation, which is an extension of the Korteweg-de Vries equation in 2+1 dimensions, and the Davey-Stewartson system, an extension of the nonlinear Schrdinger equation in 2+1 dimensions. In both instances, a system of quasilinear first-order PDEs is obtained through a multiple scales expansion and averaging conservation laws over one oscillation period of the periodic traveling wave solutions. Subsequently, the system is transformed into a hydrodynamic Whitham system, which is then utilized to investigate the transverse stability of periodic traveling wave solutions. The obtained results demonstrate excellent agreement with numerical simulations.

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MS27

Emergent Hydrodynamics of Soliton Condensates in Nonlinear Dispersive Waves

Soliton condensates can be viewed as critically dense soliton gases constrained by a given spectral (Lax) support. In my talk I outline the connection of the kinetic theory of KdV soliton condensates with modulation theory of generalised rarefaction and dispersive shock waves. Remarkably, essentially the same spectral construction applied to the focusing NLS equation enables the characterisation of established integrable turbulence in some fundamental scenarios of the development of modulational instability. The talk is based on joint works with Alex Tovbis, Thibault Congy, Giacomo Roberti, Pierre Suret and Stephane Randoux.

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MS27

Riemann Problem for Polychromatic Soliton Gases: A Testbed for the Spectral Kinetic Theory

We use Riemann problem for soliton gas as a benchmark for a detailed numerical verifica- tion of the kinetic equation describing the evolution of the density states in the nonlinear Fourier spectral phase plane. We construct weak solutions of the kinetic equation de- scribing collision of two dense, uniform soliton gases, each composed of a finite number of quasi-monochromati components. We extract the macroscopic physical observables of the associated nonlinear incoherent wave fields (integrable turbulence) for the focusing nonlinear Schrodinger equations from the the analytical spectral solution and compare them with the results of direct numerical simulations of respective polychromatic soliton gases. To numerically synthesize dense soliton gases we employ a novel method that com- bines advances in the spectral theory of the so-called soliton condensates and the recently developed effective algorithms for the numerical realization of N-soliton solutions with large N.

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MS28

The Nucleation-Annihilation Behavior for Hotspot Patterns of Urban Crime with Police Deployment

A hybrid asymptotic-numerical approach is developed to study the existence and linear stability of steady-state hotspot patterns for a three-component 1-D reaction-diffusion (RD) system that models urban crime with police intervention. Our analysis is focused on a new scaling regime in the RD system where there are two distinct competing mechanisms of hotspot annihilation and creation that, when coincident in a parameter space, lead to complex spatio-temporal dynamics of hotspot patterns. Hotspot annihilation events are shown numerically to be triggered by an asynchronous oscillatory instability of the hotspot amplitudes that arises from a subcritical Hopf bifurcation. In addition, hotspots can be nucleated from a quiescent background when the criminal diffusivity is below a saddle-node bifurcation threshold of hotspot equilibria, which we estimate accurately from an asymptotic analysis. To investigate instabilities of hotspot steady-states, the spectrum of the linearization around a two-boundary hotspot pattern is computed.

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MS28

Chaotic Front Motion in Allen-Cahn Equations with Large Scale Linear Field

It is well known that front interfaces in bistable isotropic reaction-diffusion equations are asymptotically stationary or move with constant speed. Self-organised front motion by interacting components occurs in multi-component reaction-diffusion system with one fast component governed by an Allen-Cahn equation that is coupled to slow linear equations. We consider general number of additional components and study existence, stability and bifurcations of stationary and uniformly travelling front solutions near the singular limit. Combining an Evans function and a functional analytic approach we find that the organising center for the dynamics of front speeds yields an N-th order ODE for N additional components. Analysing the normal form, for N = 3 we prove that chaotic dynamics occurs in the sense of an unfolded Shil'nikov homoclinic orbit. Numerical study guided by our analytic findings complement these results. This is joint work with Martina Chirilus-Bruckner (Leiden) and Peter van Heijster (Wageningen).

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MS28

Traveling and Standing Waves As a Consequence of Cross-Diffusion

Turing instabilities have been a big research topic in the last few years, after Alan Turing discovered that, under certain conditions, a stabilizing process can destabilize a system. In a reaction-diffusion system with two components and a diagonal diffusion matrix, the conditions for these instabilities to appear are simple and well-known. However, these are restricted only to steady heterogeneous patterns. In the last few years, they have been generalized to study Turing and Turing-wave instabilities in general n-component reaction-diffusion systems with diagonal diffusion matrices, where Turing-wave instabilities are those related to spatiotemporal patterns. In this talk, I am going to talk about the generalization of these conditions to arbitrary reaction-diffusion equations in the presence of linear cross-diffusion, and I will also highlight some natural generalizations of the theory to general reaction-diffusion equations in the presence of nonlinear (cross-) diffusion. Furthermore, I am going to show examples of spatiotemporal patterns in cross-diffusion systems that cannot have Turing or Turing-wave instabilities without cross-diffusion, together with the ideas used to assemble these examples.

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MS29

Sharp Well-Posedness for the Benjamin-Ono Equation

We will discuss a sharp well-posedness result for the Benjamin–Ono equation in the class of H^s spaces, on both the line and the circle. This result was previously unknown on the line, while on the circle it was obtained recently by Gérard, Kappeler, and Topalov. Our proof features a number of developments in the integrable structure of this system, which also yield many important dividends beyond well-posedness. This is based on joint work with Rowan Killip and Monica Visan.

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MS29

Universality in the Small-Dispersion Limit of the Benjamin-Ono Equation

This talk concerns the Benjamin-Ono (BO) equation of internal wave theory, and properties of the solution of the Cauchy initial-value problem in the situation that the initial data is fixed but the coefficient of the nonlocal dispersive term in the equation is allowed to tend to zero (i.e., the zero-dispersion limit). It is well-known that existence of a limit requires the weak topology because high-frequency oscillations appear even though they are not present in the initial data. Physically, this phenomenon corresponds to the generation of a dispersive shock wave. In the setting of the Korteweg-de Vries (KdV) equation, it has been shown that dispersive shock waves exhibit a universal form independent of initial data near the two edges of the dispersive shock wave, and also near the gradient catastrophe point for the inviscid Burgers equation from which the shock wave forms. In this talk, we will present corresponding universality results for the BO equation. These have quite a different character than in the KdV case; while for KdV one has universal wave profiles expressed in terms of solutions of Painlevé-type equations, for BO one instead has expressions in terms of classical Airy functions and Pearcey integrals. These results are proved for general rational initial data using a new approach based on an explicit formula for the solution of the Cauchy problem for BO. This is joint work with Elliot Blackstone, Louise Gassot, Patrick Gérard, and Matthew Mitchell.

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MS29

Nonlocal Benjamin-Ono Waves in Dubrovin's Integrable Quantization of the Hopf Hierachy on the Torus

Spatially periodic solutions $v(x,t)$ of the Hopf equation $\partial_t v + v\partial_x v = 0$ in one spatial dimension admit a classical hierarchy of conserved quantities $H_\ell(v) = \frac{1}{2\pi}\int_0^{2\pi} v(x,t)^\ell dx$. In 2016, Dubrovin gave a remarkable new characterization of Schur polynomials as eigenfunctions of an integrable quantization of these $H_\ell(v)$ at scale $\hbar > 0$. In 2019, I proved that the discrete eigenvalues of this quantization could be described exactly by $\hbar$-Bohr-Sommerfeld quantization of the non-local multi-phase solutions of the Benjamin-Ono equation with dispersion coefficient $\bar{\varepsilon} = \sqrt{\hbar}$. This result confirms a 2005 prediction of Abanov-Wiegmann but does not yet give an exact description of Schur polynomials themselves in terms of these non-local coherent structures. In this talk, I will discuss joint work with Robert Chang (Reed College) on the semi-classical analysis of Dubrovin's quantum Hopf hierarchy.

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MS30

New Integrable Peakon Equations and Their Properties

Peakons are peaked travelling waves that were first found as solutions to the Camassa-Holm equation arising in the theory of shallow water waves. The Camassa-Holm equation also possesses multi-peakon solutions and, remarkably, is an integrable system with a Lax pair and bi-Hamiltonian structure. These discoveries started an extensive search for and study of integrable peakon equations. This talk will present some recent work on two new integrable peakon equations that belongs to the class $m_t + f(u, u_x)m + (g(u, u_x)m)_x = 0$ of dispersive nonlinear wave equations with $m = u - u_{xx}$, and that exhibit parity non-invariance under $x \to -x$. All previously known integrable peakon equations in this class are parity invariant [S.C. Anco and E. Recio, J. Phys. A: Math. Theor. 52 (2019) 125203]. A Lax pair, bi-Hamiltonian structure, recursion operators, hierarchies of symmetries and conservation laws, multi-peakon solutions will be described for the new equations.

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MS30

Progress on Initial-Boundary Value Problems for Evolution Equations

In this talk we shall discuss the progress made during the last few years in the solving of initial-boundary value problems for evolution equations via the Fokas Method. Our focus will be on dispersive equations and systems and in particular the Korteweg-de Vries and Nonlinear Schrdinger equations with data in low regularity Sobolev spaces. Using the Fokas solution formula for the corresponding forced linear problem, we derive linear estimates that in combination with the multilinear estimates suggested by the nonlinearity make the well-posedness study of initial-boundary value problems analogous to that of initial value problems. Thus, in the framework of Bourgain spaces, we are able to obtain similar optimal well-posedness results. The talk is based on work with A. Fokas, D. Mantzavinos and F. Yan.

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MS30

Well-Posedness for Burgers Equation on the Half Line

We consider the viscous Burgers equation on the half line, and show that the corresponding initial boundary value problem is well posed in Sobolev spaces. In particular, we use the Fokas method (generalized Fourier transform method) to derive an integral equation the solution must satisfy. We then show that the operator in the equation has a fixed point using the contraction mapping theorem. In order to apply the contraction mapping theorem, we use the method of weighted continuous functions of time introduced by Kato and Fujita (1962) and later used by Bekiranov (1996) for Burgers equation on the line. These spaces allow us to handle the nonlinear terms in Burgers equation.

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MS30

Modulational Instability for Periodic Waves in the Novikov Equation

In this talk, I will discuss recent results concerning the modulational stability of smooth periodic traveling wave solutions of the Novikov equation (a Camassa-Holm like equation with cubic nonlinearity). The waves considered are constructed via local bifurcation theory and, as such, have asymptotically small amplitude of oscillation. Using rigorous spectral perturbation theory, we derive a condition guaranteeing the spectral instability of such solutions to perturbations associated with slow modulations of the underlying wave. This is joint work with Brett Ehrman, Stephane Lafortune and Wesley Perkins.

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MS31

Hydrodynamic Quantum Analogs

Since 2005, numerous studies have shown that droplets walking on a vibrating fluid bath exhibit features previously thought to be exclusive to the microscopic, quantum realm. These walking droplets are an example of wave-particle duality on the macrocopic scale; moreover, they are the first macroscopic realization of a pilot-wave system of the form proposed for microscopic quantum dynamics by Louis de Broglie in the 1920s. New experimental and theoretical results allow us to explore its potential and limitations as a quantum analog, and so redefine the boundary between classical and quantum. Theoretical descriptions of the hydrodynamic system allow us to forge links with existing quantum pilot-wave theories. Fledgling, trajectory-based descriptions of quantum dynamics, informed by the hydrodynamic system, are explored. Particular attention is given to illustrating how the non-Markovian droplet dynamics may give rise to features that are taken as evidence of quantum nonlocality in their microscopic counterparts.

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MS31

Morphological Attractors in Natural Convective Dissolution

Ever-changing geological features on this planet never fail to capture our imagination and inspire new scientific advances. Among them, the formation of stone forests is one striking geomorphology caused by dissolution and fluid-structure interactions in nature. Recent experiments demonstrate how a soluble body placed in a fluid spontaneously forms a dissolution pinnacle a slender, upward pointing shape that resembles naturally occurring karst pinnacles found in stone forests. This unique shape results from the interplay between interface motion and the natural convective flows driven by the descent of relatively heavy solute. In this talk, we will discuss a class of exact solutions that act as attractors for the shape dynamics in two and three dimensions. Intriguingly, the solutions exhibit large but finite tip curvature without any regularization, and they agree remarkably well with experimental measurements. The relationship between the dimensions of the initial shape and the final state of dissolution may offer a principle for estimating the age and environmental conditions of geological structures.

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MS31

Self-Assembly in Stratified Fluids

We discuss novel behavior concerning particles suspended at similar depths in a stratified water column where we discovered an unexpected and surprising self-assembly phenomena, https://www.nature.com/articles/s41467-019-13643-y. Here, particles create diffusive induced flows due to the no-flux boundary condition which requires that concentration contours intersect boundaries orthogonally. These flows create effective forces of attraction between particles which drive the system to solve jig-saw like puzzles on their way to forming a large scale compact disc. We overview the experimental discovery and theoretical underpinnings of this behavior. In turn, we present new findings in different limiting configuations and overview how different boundary conditions modify the assembly phenomenon

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MS32

Extreme Superposition: Models for Large-Amplitude Rogue Waves

Rogue waves, often referred to as freak waves or monster waves, are spatially localized disturbances of a background field that are also temporally localized, making them appear seemingly out of nowhere. These waves have long captured the attention of seafarers and scientists alike due to their unpredictable and destructive nature. Focusing nonlinear Schrdinger equation serves as a universal model for the amplitude of a wave packet in a general one-dimensional weakly-nonlinear and strongly-dispersive setting that includes water waves and nonlinear optics as special cases. In the setting of this model, a special exact solution exhibiting rogue-wave character was found by D. H. Peregrine in 1983, and since then, Peregrines solution has been generalized to a family of solutions of arbitrary order, involving more parameters as the order increases. These parameters can be adjusted to obtain rogue wave solutions of maximal amplitude for a given order. In this talk, we will describe several recent results concerning such maximal-amplitude rogue wave solutions in the asymptotic regime of large order, which effectively is a large-amplitude regime. This is joint work with Peter D. Miller and Liming Ling.

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MS32

Nonlinear Schrdinger with Periodic Boundary Conditions: Asymptotics, Inverse Scattering and Exactly Solvable Potentials

The behavior of solutions of integrable nonlinear PDEs with periodic boundary conditions has received considerable interest in recent years, due in part to the connection between these problems and the study of soliton and breather gases. In this talk I will review some recent results on the subject, focusing on two studies of the nonlinear Schrodinger equation: (i) The characterization of a two-parameter class of exactly solvable elliptic potentials, and (ii) The development of the inverse problem in the inverse scattering transform via a Riemann-Hilbert problem approach.

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MS32

Self-Similar Collapse to the Nonlinear Schrdinger Equation and Beyond

In this talk, we will focus on the self-similar collapse of the (1+1)-dimensional NLS equation with general nonlinearity exponent σ. Upon performing a dynamic rescaling on the NLS, we will present a general method that is capable of identifying self-similar waveforms as steady-state solutions in the so-called “co-exploding frame’. Then, we will bring forth bifurcation analysis techniques as well as computational methods associated with them in order to perform a spectral stability analysis of the pertinent waveforms as a function of the nonlinear exponent σ. Most importantly, conclusions will be drawn about how the spectral picture in the co-exploding/self-similar frame connects with the one in the original frame. If time permits, connections with the identification of rogue waves as self-similar patterns will be discussed as well as recent advances on the generalized KdV equation.

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MS32

Numerical Inverse Scattering Transform for the Defocusing Nonlinear Schrdinger Equation with Non-Zero Boundary Conditions and Box-Type Initial Conditions

In this talk, we present a method to compute the inverse scattering transform (IST) for the defocusing nonlinear Schrdinger (dNLS) equation with non-zero boundary conditions (NZBCs) and a box-type initial condition by solving the associated RiemannHilbert (RH) problem numerically. We discuss the long-time asymptotics of the problem using the nonlinear steepest descent method. The space-time domain for x and t is divided into three regions, depending on the value of the parameter ξ=x/2t: the solitonic region when $|\xi| < 1$, the soliton-less region when $|\xi| > 1$, and the collision-less region, when $|\xi| = 1$. We compare our results with the works of Cuccagna and Jenkins, On the asymptotic stability of N-soliton solutions of the defocusing nonlinear Schrdinger equation, and Wang, Zhaoyu and Fan, Defocusing NLS equation with nonzero background: Large-time asymptotics in a solitonless region, where the long-time asymptotics of the dNLS equation in the solitonic and soliton-less regions, have been previously analyzed. In addition, the solution of the dNLS equation is computed in the collision-less region, where the asymptotics are not known rigorously. Appropriate deformations of the RH problem are incorporated in each region, so that the IST can be evaluated numerically for any arbitrary point in the (x,t) domain. Finally, we compare our results with a time-evolution numerical method, and we present some plots to illustrate the comparison.

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MS33

A Hele-Shaw Newton's Cradle

I will present a model for the motion of approximately circular bubbles in a Hele-Shaw cell. The bubble velocity is determined by a balance between the hydrodynamic pressures from the external flow and the drag due to the thin films above and below the bubble. We find that the qualitative behaviour depends on a dimensionless parameter $\delta \propto \mathrm{Ca}^{1/3} R/h$, where Ca is the capillary number, R is the bubble radius and h is the cell height. An isolated bubble travels faster than the external fluid if $\delta > 1$ or slower if $\delta < 1$, and the theoretical dependence of the bubble velocity on δ is found to agree well with experimental observations. Furthermore, I show how the effects of interaction with other bubbles also depend on the value of δ. For example, with two bubbles of different radii we predict and observe a bubble rollover effect. Additionally, in a train of three identical bubbles travelling along the centre line, the middle bubble either catches up with the one in front (if $\delta > 1$) or is caught by the one behind (if $\delta < 1$), forming what we term a Hele-Shaw Newton's cradle.

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MS33

On the Bounce: Capillary Droplet Rebound and Nonlinear Wave Interactions

We consider the canonical setup of a millimetric drop impacting a deep bath of the same fluid. Measurements of the droplet trajectory are compared directly to the predictions of a newly developed quasi-potential model, as well as fully resolved unsteady Navier-Stokes direct numerical simulations (DNS). Both theoretical techniques resolve the time-dependent bath interface shape, droplet trajectory, and droplet deformation. In the quasi-potential model, the droplet and bath shape are decomposed using orthogonal function decompositions leading to a set of coupled damped linear oscillator equations solved using an implicit numerical method. The underdamped dynamics of the drop are directly coupled to the response of the bath through a single-point kinematic match condition, which we demonstrate to be an effective and efficient technique. The hybrid methodology has allowed us to unify and resolve interesting outstanding questions on the rebound dynamics of the multi-fluid system (Alventosa, Cimpeanu and Harris, JFM 957, 2023). We will also explore recent insight into three-dimensional and confinement effects within this rich multi-fluid system.

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MS33

Water Waves with Vorticity and the Schwarz Function

The theory of water waves is centuries old, but it remains a vibrant area of research. Most theoretical work on water waves takes the flow to be irrotational, but there is growing recent interest in the effect of vorticity on the structure of the waves. The assumption of irrotationality has the theoretical advantage that complex analysis techniques can be used to analyze the problem in the two-dimensional setting. This talk will present a novel theoretical formulation of the problem of steadily-travelling water waves in the presence of vorticity (where the assumption of irrotationality is dropped). The approach is based on the notion of a Schwarz function of a curve. It unifies our understanding of several recent results in the water wave literature and provides a wealth of new exact mathematical solutions to this challenging free boundary problem.

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MS33

Stability of Hydroelastic Waves

Two-dimensional periodic travelling hydroelastic waves on water of infinite depth are investigated numerically. The stability of these periodic waves is examined using a surface-variable formulation in which a linearised eigenproblem is stated on the basis of Floquet theory and solved numerically. The eigenspectrum is discussed encompassing both superharmonic and subharmonic perturbations. This is joint work with mark Blyth (UEA) and Zhan Wang (Chinese Academy of Sciences, Beijing)

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MS34

Controlling Cell Exploration and Oscillation Using Secreted Footprints

For eukaryotic cells to heal wounds, respond to immune signals, or metastasize, they must migrate, often by adhering to extracellular matrix. Cells may also deposit matrix, leaving behind a footprint that influences their crawling. Recent experiments showed that epithelial cells on micropatterned adhesive stripes move persistently in regions they have previously crawled on, where footprints have been formed, but barely advance into unexplored regions, creating an oscillatory migration of increasing amplitude. Here, we explore through mathematical modeling how footprint deposition and cell responses to footprint combine to allow cells to develop oscillation and other complex migratory motions. We simulate cell crawling with a phase field model coupled to a biochemical model of cell polarity, assuming local contact with the deposited footprint activates Rac1, a protein that establishes the cell's front.

Depending on footprint deposition rate and response to the footprint, cells on micropatterned lines can display many types of motility, including confined, oscillatory, and persistent motion. On 2D substrates, we predict a transition between cells undergoing circular motion and cells developing an exploratory phenotype. Consistent with our computational predictions, we find in earlier experimental data evidence of cells undergoing both circular and exploratory motion.

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MS34

Localized States in the Actin Cortex of Animal Cells

The actin cortex of animal cells plays an important role in cell migration and division. It is a quasi two-dimensional network of filamentous polymers that interact with a large number of associated proteins. Among these are notably molecular motors that generate mechanical stress in the network, such that it constitutes an active material. Stress generation is affected by chemical reaction networks. In such systems, the coupling between mechanics and chemistry enables self-organization, for example, into waves. Recently, contractile systems were shown to be able to spontaneously develop localized spatial patterns. Here, we show that these localized patterns can present intrinsic spatiotemporal dynamics, including oscillations and chaotic dynamics. We discuss their physical origin and bifurcation structure.

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MS34

Somitogenesis: a Mechanism for Controlled Localised Pattern Establishment

The first segmented structures to appear in developing vertebrate embryos are the somites. They are laid down in a localised periodic pattern that in fact defines the essence of each vertebrate body plan, including us human beings. Somitogenesis follows a clock-like rhythm, in which each temporal oscillation in gene expression is translated into the addition of a single localised spatial wave. In my talk I will focus on chick somitogenesis and, using a combination of PDEs and the Cellular Potts Model as an integrative unit, will show that the known biomolecular network and modifications in chemotaxis and adhesion can explain this segmentation into somites, in terms of a self-organised transition from a temporal to a spatial pattern. Through this study we not only identify the mechanism underlying the localised pattern formation, but I will also demonstrate which aspects of the mechanism are highly robust and which elements are in contrast sensitive to the specific molecular and biophysical circumstances. This allows us to assess to which extent such a localised biological patterning mechanism can be evolutionary conserved and when and how divergent patterning between species could or should be expected.

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MS34

Emergence of Rogue-like Waves in a Reaction-diffusion System: Stochastic Output From Deterministic Dynamics

Rogue waves are an intriguing nonlinear phenomenon arising across different scales, ranging from ocean waves through optics to Bose-Einstein condensates. We describe the emergence of rogue wave-like dynamics in a reaction-diffusion system that arise as a result of a subcritical Turing instability. This state is present in the regime where all time-independent states are unstable, and consists of intermittent excitation of spatially localized spikes, followed by collapse to an unstable state and subsequent regrowth. We characterize the spatiotemporal organization of spikes and show that in sufficiently large domains the dynamics are consistent with a memoryless process.

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MS35

The Instabilities of Finite-Depth Stokes Waves

I will present a progress report on numerical results for the stability spectrum of Stokes wave solutions to the full water wave problem in finite depth. Following the work of Dyachenko and Semenova, we apply the Fourier-Floquet-Hill Method to a conformal mapping reformulation of the water wave problem to compute both sub- and co-periodic instabilities.

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MS35

Stability of Near-Extreme Solutions of the Whitham Equation

The Whitham equation is a model for the evolution of small-amplitude, unidirectional waves of all wavelengths on shallow water. It has been shown to accurately model the evolution of waves in laboratory experiments. We compute 2π-periodic traveling-wave solutions of the Whitham equation and numerically study their stability with a focus on solutions with large steepness. We show that the Hamiltonian oscillates as a function of wave steepness when the solutions are sufficiently steep. We show that a superharmonic instability is created at each extremum of the Hamiltonian and that between each extremum the stability spectra undergo similar bifurcations. Finally, we compare these results with those from the Euler equations.

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MS35

Instability of Stokes Waves

The study of ocean waves, especially surface gravity waves, is essential for understanding the formation of rogue waves and whitecaps within ocean swell. Waves that propagate from the epicenter of a storm can be treated as unidirectional. In this presentation, we will examine periodic traveling waves on the free surface of an ideal two-dimensional fluid of infinite depth. Specifically, we will introduce surface waves of permanent shape, also known as Stokes waves and discuss their stability.

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MS35

Traveling Fronts Connecting Distinct Periodic Orbits

We consider traveling wave solutions of Hamiltonian PDEs on the real line, asymptotic to distinct periodic solutions at $\pm\infty$. Utilizing Whitman modulation theory, jump conditions that constitute necessary conditions for the existence of such traveling fronts are derived. These jump conditions are equivalent to the conserved integrals of motion in a Hamiltonian dynamical system. Numerical results are presented for traveling waves solutions of the Kawahara Equation and a family of Boussinesq equations which serve as models of water waves with a strong surface tension. The results presented here include the construction of hydraulic jumps with oscillatory tails in surface water waves.

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MS36

Periodic Waves for the Regularized Camassa-Holm Equation: Existence and Spectral Stability

In this talk, we consider the existence and spectral stability of periodic traveling wave solutions for the regularized Camassa-Holm equation. For the existence of periodic waves, we employ tools from bifurcation theory to construct waves with the zero mean property and prove that waves with the same property do not exist for the Camassa-Holm equation. Regarding the spectral stability, we analyze the difference between the number of negative eigenvalues of a convenient linear operator, restricted to the space constituted by zero-mean periodic functions, and the number of negative eigenvalues of the matrix formed by the tangent space associated with the low-order conserved quantities of the evolution model. If time allows, we will also present some orbital stability results in the energy space.

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MS36

Asymptotic Stability of Solitary Waves in Shallow Water Models

In this talk, we shall briefly report a recent asymptotic stability result of smooth solitons and multi-solitons in energy space for the Camassa-Holm (CH) equation. We show that a CH solution initially close to a soliton, once translated, converges weakly in H^1 to a possibly different soliton as time $t \to \infty$. The proof is motivated by the bi-Hamiltonian structure of the CH equation and a Liouville type theorem for the CH flow close to the solitons. The new ingredient in the proof of Liouville theorem is by employing the completeness relations of square eigenfunctions of the CH recursion operator. Some applications are presented in classifications of solutions of linear problems related to KdV and mKdV equations. This is a joint work with R. M. Chen, Y. Lan and Y. Liu.

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MS36

Weak Diffusive Stability of Zigzag Roll Solutions on the Cylindrical Domain

Roll solutions with zigzag wavenumbers in the Swift-Hohenberg equation (SHE) defined on the cylindrical domain are shown to be nonlinearly stable with algebraic decay rate $t^{-\frac{1}{4}}$, weaker than the typical diffusive decay rate t^{-1}. This work is a sequel to the previous work [?], where the physical domain was instead the Euclidean plane $\mathbf{R}^2$ and the decay rate was $t^{-\frac{3}{4}}$. While in both cases weak linear decay and quadratic nonlinearity still lead to nonlinear stability results, the cylindrical case admits even weaker linear decay than the planar case. As a result, the mode filter decomposition method, which is essentially a linear normal form and works for the planar case, is not applicable here and we instead exploit a phase modulation scheme, which is a nonlinear normal form. On one hand, the phase modulation scheme does lead to a refined splitting of neutral and stable modes. On the other hand, the system under the phase modulation scheme becomes quasilinear and maximal regularity results are employed to close the fixed point argument.

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MS37

Adapting Taylor Dispersion to Microfluidics Scale.

Microfluidic techniques can provide mathematicians with small labs and limited funding accessible platforms to perform experiments relevant for a variety of engineering applications. In the present work, we detail a versatile and accessible experimental setup and protocol developed to observe the phenomenon of Taylor Dispersion at the microscale. We build on a recent rapid-prototyping technique to manufacture custom microchannels on site using inexpensive materials and a commercial craft cutter. Then, we employ these microchannels to perform low-cost, repeatable passive tracer experiments tracking the dispersion of fluorescein dye solutions as we vary the channel cross-sectional aspect ratios. The experimental data is benchmarked against Taylor Dispersion and allows for a simple way of computing the solute enhanced diffusivity and dispersion coefficient. Ongoing and future directions will be discussed. This work is funded by NSF CBET-1902484 and the Simons Foundations Travel Support for Mathematicians program.

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MS37

New Measurements of Bores, Solitons, and Hydraulic Jumps in Towed Topography

We revisit the seminal experiment of wave generation by flow over topography (Lee, Yates and Wu, 1989, Lee, 1985), whereby a shallow, steady current over a localized bottom bump can act as a periodic source of upstream running long waves. We explore new parametric regimes in the two-parameter space of incoming stream velocity (Froude number) and topography amplitude (ratio of bump height and undisturbed fluid depth) in our 27m wave tank with towed topography, and compare our data with numerical simulations and theoretical predictions.

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MS37

Vortex Reflections at Air Water Interfaces

We study experimentally how a vortex ring in water interacts with an air-water interface. Near-perfect reflections of strong vortex rings are observed when they are issued and run towards the interface with anincidence angle greater than a threshold value. This observed phenomenon is much like a light beam experiencing total internal reflection (TIR). We investigate the interaction by simulating a vortex-sheet-andvortex-pair model, finding that it captures the essential dynamics. The simulation, and a further simplified model which considers the conservation of flux or momentum, explain the vortex-ring reflection. Our three approaches, experiment, numerical simulation and theory, render a better understanding of how vortex rings interact with boundaries.

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MS38

Steady States and Dynamics of the Ericksen-Leslie Model for Nematic Liquid Crystals

In this talk we consider nematic liquid crystal placed between two parallel plates. We investigate this set-up by use of the Ericksen-Leslie model with certain boundary conditions to describe this physical system. This model provides us with very rich phenomena. We will first look into steady states in the system and then study the stability of these steady states using numerical methods. These steady states fall into a variety of cases which the study of shows a variety of dynamics including the presence of a saddle node bifurcation and further dynamics of the unstable states shows the evidence of the existence of heteroclinic orbit.

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MS38

Well-Posedness of a Higher-Order Nonlinear Schrdinger Equation on a Finite Interval

The higher-order nonlinear Schrdinger (HNLS) equation is a more accurate alternative to the standard NLS equation when studying wave pulses in the femtosecond regime. It arises in a variety of applications ranging from optics to water waves to plasmas to Bose-Einstein condensates. In this talk, we consider the initial-boundary value problem for HNLS on a finite interval in the case of a power nonlinearity. We establish the local well-posedness of this problem in the sense of Hadamard (existence and uniqueness of the solution as well as its continuous dependence on the data) for initial data in the Sobolev space H^s on a finite interval and boundary data in suitable Sobolev spaces determined by the regularity of the initial data and the HNLS equation. The proof relies on a combination of estimates for the linear problem and nonlinear estimates, which vary depending on whether $s > 1/2$ or $0 \leq s < 1/2$. The linear estimates are established by using the explicit solution formula obtained via the unified transform method of Fokas. This is a joint work with Dionyssis Mantzavinos and Turker Ozsari.

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MS38

Jumps and Cusps: Talbot Effect in Non-Periodic Dispersive Systems

We address the question of whether the Talbot (revival) effect is present in two benchmark linear dispersive boundary value problems which arise in applications; the Airy equation and the Schrödinger equation for the dislocated Laplacian, both with boundary conditions of Dirichlet-type. We prove that, at suitable times, jump discontinuities in the initial profile are revived in the solution, not only as jump discontinuities but also as logarithmic cusp singularities. We explicitly describe these singularities and show that their formation is due to the interaction of the periodic Hilbert transform with the underlying spatial operator.

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MS38

Recent Progress in the Spectral Theory of Soliton Gases for Integrable Equations

Soliton gas for integrable equations is introduced through the thermodynamic limit of multi-phase (finite gap) solutions. This limit can be characterized by the growing genus 2N of the corresponding Riemann surfaces combined with simultaneous (exponentially fast in N) shrinking of the bands. We discuss recent developments of the theory, including the average densities and fluxes of solution gases and condensates, the thermodynamic limit of quasimomentum and quasienergy differentials, non bound state soliton condensates, periodic soliton gases, etc.

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MS39

The Birkhoff-Rott Integral for Non-Decaying, Non-Periodic Vortex Sheets

The Birkhoff-Rott integral is a singular integral which expresses the velocity on a vortex sheet. The typical form of the Birkhoff-Rott integral converges for vortex sheets which are asymptotically flat at infinity, but in the spatially periodic case the integral may be carefully summed over periodic images. In the non-decaying, non-periodic case, it is less clear how to express this velocity. We will give a single new formula for the Birkhoff-Rott integral which unifies the decaying and periodic cases and which is valid more generally as well. We expect this will have application to well-posedness theory for water waves with spatially quasiperiodic or uniformly local Sobolev data. In the well-posedness theory of water waves, one common tool is approximation of the Birkhoff-Rott integral by the Hilbert transform, and we will accordingly give a new representation of the Hilbert transform.

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MS39

Modulation of Short Surface Waves by a Long Internal Wave

Long internal gravity waves in density-stratified oceans have been known to change substantially the dynamics of the ocean surface. Observed surface signatures characterized by increased surface wave steepness are attributed to modulated short surface waves through their with slowly-varying surface currents induced by long internal waves. Using asymptotic models for a two-layer system with a free surface, near-resonant interactions between short surface and long internal waves are studied and the resulting surface wave modulation is discussed in comparison with observations.

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MS39

Nonlinear Concentric Water Waves of Moderate Amplitude

We consider the outward-propagating nonlinear concentric water waves within the scope of the 2D Boussinesq system. The problem is axisymmetric, and we derive the slow radius versions of the cylindrical Korteweg - de Vries (cKdV) and extended cKdV (ecKdV) models. Numerical runs are initially performed using the full axisymmetric Boussinesq system. At some distance away from the origin, we use the numerical solution of the Boussinesq system as the ”initial condition” for the derived cKdV and ecKdV models. We then compare the evolution of the waves as described by both reduced models and the direct numerical simulations of the axisymmetric Boussinesq system. The main conclusion is that the extended cKdV model provides a much more accurate description of the waves and extends the range of validity of the weakly-nonlinear modelling to the waves of moderate amplitude. As a by-product of our study we also clarify the range of validity of Johnson’s approximation for the evolution of the concentric wave with the initial profile of a KdV soliton. This is joint work with Nerijus Sidorovas, Dmitri Tseluiko and Wooyoung Choi.

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MS39

Extended KdV-type Equations for Internal Waves Over Variable Bottom Topography

For a two-layer flow, the Miyata-Choi-Camassa (MCC) model is considered in the context of plane waves, as well as concentric ring waves, under the rigid-lid approximation over a time-independent variable bottom topography. We derive the extended Korteweg-de Vries (KdV) type models for the long internal waves incorporating a slowly varying bottom topography. This is done in the context of plane waves and concentric ring waves, resulting in extended KdV (eKdV) and extended concentric KdV (ecKdV) models with variable coefficients according to the topography. The solutions of the reduced KdV-type models are then studied numerically in a case study. This is joint work with Karima Khusnutdinova, Dmitri Tseluiko, and Wooyoung Choi.

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MS40

Invasion Fronts in the Presence of a Slowly-Varying Parameter

Nonlinear reaction-diffusion equations have been shown to exhibit a wide variety of behaviors, including invasion fronts and pattern formation. We study properties of invasion fronts in the presence of a slowly-varying and increasing parameter. Using the prototypical Fisher-KPP equation, we find this parameter induces novel acceleration of the front which is different than what is predicted by a frozen-coefficient marginal stability analysis. Using a Green's function analysis we not only obtain accurate leading-order predictions for the front location but also obtain the second order correction. We make rigorous our results using comparison principles and a scaling-variables analysis. We also examine pattern-forming fronts in a slowly-varying complex Ginzburg-Landau equation. Here we use a similar analysis to predict the slowly-varying oscillation frequency, and thus the local wavenumber, in the leading edge, and a Burger's modulational analysis to characterize the wavenumber mixing in the wake.

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MS40

Differential Geometric Bifurcation Problems in PDE2path

We describe how geometric partial differential equations can be treated with the numerical continuation and bifurcation toolbox pde2path. For example, such equations describe the interface between two liquids in physics and biology. Determining the shape of cells is one of these examples, for which there are a variety of competing models. Here we focus on the spontaneous curvature (SCM) and the bilayer coupling model (BCM). Both lead to the same Euler-Lagrange equation of the form

$$\Delta H + 2H(H^2 - K) + c_0 K - 2c_0^2 H - 2\lambda_1 H - \lambda_2 = 0,$$

up to a parameter transformation, where Δ is the Laplace-Beltrami operator, H and K are the mean and the Gaussian curvature, respectively, and $\lambda_{1,2}$ are Lagrange multipliers. We investigate solutions with spherical (cells) and cylindrical topology (tissues). For both, we recover known axisymmetric solutions, and, moreover, bifurcations to non-axisymmetric branches. For the SCM, it is generally believed, and confirmed by us, that there are no non-axisymmetric stable solutions. However, in vitro experiments found non-axisymmetric solutions, and we numerically find locally stable non-axisymmetric solutions in the BCM. For cylindrical cases, we work with either clamped or periodic boundary conditions, and find a large variety of unexpected non-axisymmetric stable solutions.

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MS40

Exploring the Impact of Changing Slope on Dryland Vegetation Band Patterns, Within a Flow-kick Modeling Framework

Large-scale patterns of vegetation, in the form of regularly spaced bands transverse to gentle slopes (0.5-2% grade), have been observed in dryland regions around the globe. We have developed a flow-kick" reaction-diffusion modeling framework for investigating these ecosystems. The flow, which is applied in the dry periods between storms, is a simple reaction-diffusion model. It captures the local interaction between soil moisture and biomass density fields, with seed dispersal modeled as diffusion of biomass. During the flow phase of the model, soil moisture is continuously lost through evaporation and transpiration. It is then replenished via spatially heterogeneous kicks that result from rare, randomly-timed rainstorms. The spatial heterogeneity of the kick results from positive feedbacks between the biomass distribution and soil-moisture increase, and depends on the storm strength, another random variable of the model. The shape of the terrain also influences the re-distribution of surface water into the soil, following a storm kick, since it determines the overland surface water flow speed during rain storms. The focus of this talk is on how changing the elevation gradient impacts the characteristics of vegetation patterns. A number of open research questions will be identified.

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MS41

Transverse Instability of Stokes Waves in Finite Depth

The first proof of the transverse instability of small-amplitude, periodic water waves in finite depth is presented. Key details of the proof will be emphasized, and the fundamental analytical results will be connected to previous numerical and formal asymptotic investigations.

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MS41

Small Amplitude Water Waves in a Triangular Domain

We discuss some dynamical questions of a model for small amplitude free surface potential flow in a triangular domain. The formulation of the problem uses a parametrization of the free surface by an auxiliary harmonic function, and includes Lagrangian and Hamiltonian formulations. We present some results on cubic and quartic resonances and approximate normal modes of low frequency. This is joint work with R.M. Vargas Magaa, U. Bergen, Norway.

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MS41

Transverse Instability in a Full-dispersion Kadomtsev-Petviashvili Equation

We present a full-dispersion version of Kadomtsev-Petviashvili (KP) equation and study transverse instability of one-dimensional periodic traveling wave solutions with respect to two-dimensional periodic or non-periodic transverse perturbations.

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MS41

Comparisons Between NLS-Like Model Predictions and Experimental Measurements

The nonlinear Schrdinger (NLS) equation and its generalizations model the evolution of modulated wave trains on deep water. We wrote Julia codes that numerically solve the temporal NLS, dissipative NLS, Dysthe, viscous Dysthe, and dissipative Gramstad-Trulsen equations. We used these codes to compare the predictions of these models with the experimental wave tank data collected by Diane Henderson at Penn State University. We found that the dissipative models significantly outperformed the conservative models. Our goal is to make comparisons with the spatial generalizations of these equations and, ultimately, the new broadband generalization of the NLS equation derived by Yan Li from the University of Bergen.

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MS42

Linear Evolution PDEs on Semi-unbounded Domains Revisited: A Novel Rigorous Approach and Unexpected Phenomena

We shall discuss some of our recent findings concerning the rigorous analysis of fully non-homogeneous initial-boundary-value problems for several renowned evolution partial differential equations (PDE) formulated in a quarter-plane. These PDE emerge in the applied sciences as models of processes pertaining to water waves, continuum mechanics, heat-mass transfer, solid-fluid dynamics, electron physics, petroleum engineering, nanotechnology, etc. Our work is based on the synergy between: (i) the groundbreaking and celebrated Fokas unified transform method (UTM) and (ii) a new approach, introduced in [A. Chatziafratis, 2019, Rigorous Analysis of the Fokas Method for Linear Evolution PDE on the Half-Space, Thesis, University of Athens], for the rigorous refinement and extension of the UTM as well as for analytical investigation of a miscellany of qualitative properties of such PDE, e.g. constructive existence, uniqueness and spatiotemporal asymptotics. One of the salient aspects of this work is the proper a posteriori justification, for the first time, of the validity of formally derived UTM solutions representations, including reconstruction -in limits- of prescribed initial and boundary data. Various surprising new phenomena (e.g., breakdown, blow-up and instability effects) will be highlighted. Further investigations, extensions and implications, along with challenges and open problems, shall be indicated too, which effectively open up an avenue for future explorations.

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MS42

The Unified Transform Method Applied to Linear, Variable-Coefficient Partial Differential Equations

We generalize the Unified Transform Method (UTM) for solving linear, constant-coefficient PDEs to linear, variable-coefficient PDEs by breaking the domain into subdomains, on which we solve a constant-coefficient problem. We use the UTM to solve the resulting interface problem and take the limit as the number of interfaces approaches infinity. This produces an explicit representation of the solution, from which we can determine properties of the solution directly. We expect the method to generalize to higher-order and non-self-adjoint problems. We hope the method will have applications for nonlinear, variable-coefficient problems and linear stability problems.

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MS43

Singularity and Invariants in 2D Fluid with a Free Surface

We consider the classical problem of 2D fluid flow with a free boundary. Recent works strongly suggest that squareroot type branch points appear naturally in 2D hydrodynamics. We illustrate how the fluid domain can be complemented by a virtual fluid, and the equations of motion are transplanted to a branch cut (a vortex sheet) in the conformal domain. A numerical and theoretical study of the motion of complex singularities in multiple Riemann sheets is suggested. Unlike preceding work for dynamics of singularities: the short branch cut approximation, and the study of viability of meromorphic solutions in fluid dynamics, the present approach neither simplifies the equations of fluid flow, nor uses local Laurent expansions. Instead the new approach is based on analytic functions and allows construction of global solutions in 2D hydrodynamics. A natural extension of the approach considers fluid flows described by many pairs of squareroot branch points

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MS43

Exact Solution and Integrability of Ballistic Motion of Fluid with Free Surface

A fully nonlinear dynamics for potential flow of ideal incompressible fluid with a free surface is considered in two dimensional geometry. A fluid is assumed to be moving at large distances either towards or away from the origin which can be considered as a version of ballistic motion. An infinite set of exact solution is found including formation of droplets and cusps on a free surface. These solutions are characterized by motion of complex singularities outside of fluid and can be obtained from fully integrable exact reductions of fluid dynamics.

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MS43

The Influence of Vorticity and Surface Tension on the Stability of Water Waves

In this talk, we discuss the stability of periodic traveling wave solutions to the Euler equations under the influence of a linear shear and gravity. We explore the regime where the flow is dominated by the strength of the shear relative to the strength of gravity. In this regime, we show that the growth rates associated with the spectral stability of non-trivial traveling wave solutions grows without bound - precisely when the Taylor sign condition is violated. We compare these results with the results due to Blythe and Parau based on the work of Hur and Wheeler in the case of zero gravity. Specifically, we introduce gravity as a free parameter and use a continuation method to show that the results in the limiting zero gravity case are in agreement.

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MS43

Transverse Instability of Stokes Waves

More than four decades ago, numerical simulations showed that Stokes waves of small amplitude are unstable when subjected to transverse perturbations. I will present the first rigorous proof of this phenomenon. The proof is joint work with Ryan Creedon and Huy Nguyen.

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MS45

On Maxwell-Bloch Systems with Inhomogeneous Broadening and One-Sided Nonzero Background

The inverse scattering transform is developed to solve the Maxwell-Bloch system of equations that describes two-level systems with inhomogeneous broadening, in the case of optical pulses that do not vanish at infinity in the future. The direct problem, which is formulated in terms of a suitably-defined uniformization variable, combines features of the formalism with decaying as well as non-decaying fields. The inverse problem is formulated in terms of a 2×2 matrix Riemann-Hilbert problem. A novel aspect of the problem is that no reflectionless solutions can exist, and solitons are always accompanied by radiation. At the same time, it is also shown that, when the medium is initially in the ground state, the radiative components of the solutions decay upon propagation into the medium, giving rise to an asymptotically reflectionless states. Like what happens when the optical pulse decays rapidly in the distant past and the distant future, a medium that is initially excited decays to the stable ground state as $t \to \infty$. Finally, the asymptotic state of the medium and certain features of the optical pulse inside the medium are considered, and the emergence of a transition region upon propagation in the medium is briefly discussed.

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MS45

Reconstruction of Evolving Percepts in Binocular Rivalry from Nonlinear Neuronal Network Dynamics

When the two eyes are presented with highly distinct stimuli, the resulting percept generally switches every few seconds between the two monocular images in an irregular fashion, giving rise to a phenomenon known as binocular rivalry. While a host of studies have explored potential mechanisms for binocular rivalry in the context of model dynamics in response to simple stimuli, here we investigate rivalry directly through complex stimulus reconstructions based on the activity of a two-layer neuronal network model with competing downstream pools driven by disparate monocular stimuli composed of image pixels. To estimate the dynamic percept, we derive a linear input-output mapping rooted in the nonlinear network dynamics and iteratively apply compressive sensing techniques for signal recovery. Utilizing a dominance metric, we identify when percept alternations occur and use data collected during each dominance period to generate a sequence of percept reconstructions. In light of evidence that individuals with autism exhibit slow percept switching in binocular rivalry, we corroborate the hypothesis that autism manifests from reduced inhibition by systematically probing our model alternation rate across choices of inhibition strength.

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MS45

New Nonlinear Propagating Modes at the Fringes of Optical Fibers

I will first present new results on the existence of large amplitude coherent structures in nonlinear Schrödinger equation. Subsequently, I will discuss their connection with modes propagating at the fringes of optical fibers and their possible contribution to filamentation. Part of this work is in collaboration with H. Uecker from U. Oldenburg, Germany and P. Kevrekidis from U. Massachusetts at Amherst.

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MS45

Dynamics of Sensory Integration of Olfactory and Mechanosensory Input Within the Insect Antennal Lobe

Air turbulence ensures that in a natural environment insects tend to encounter odor stimuli in a pulsatile fashion. The frequency and duration of odor pulses varies with distance from the source, and hence successful mid-flight odor tracking requires resolution of spatiotemporal pulse dynamics. This requires both olfactory and mechanosensory input (from wind speed), a form of sensory integration observed within the antennal lobe (AL). In this work, we employ a model of the moth AL to study the dynamics of sensory integration of olfactory and mechanosensory input within the AL network. We present our experimental data that clearly demonstrates that AL neurons respond, in dynamically distinct ways, to both chemosensory and mechanosensory input, with responses to mechanosensory input tending to be more transient and temporally precise than those to olfactory input. We use our model to explore the dynamical mechanisms underlying the bimodal AL responses revealed in our experimental work and show, within our model, that mechanosensory input enhances the tracking of odor pulses by the AL. Finally, we propose a novel hypothesis about the role of mechanosensory input in sculpting AL dynamics and the implications for biological odor tracking.

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MS46

Existence of Steady Laser-Forced Boussinesq Flows

The existence of steady internally-forced Boussinesq flow is discussed. The forcing is a model for laser propagation through an absorbing fluid. Two distinct existence proofs are presented. The first is based on a contraction mapping, the second builds the solution via a Stokes expansion. Both form the basis for numerical methods. The proofs and numerical methods are compared, with implications to laser-fluid experiments.

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MS46

Using Rigorous Computation to Prove Stability of Traveling Waves

Using a combination of analytic and computer assisted methods of proof, we prove stability of traveling front solutions to the KdV-Burgers equation. The methods apply much more generally. In this talk we focus on the rigorous computations involved in the computer assisted methods of proof. We use a Newton-Kantorovich argument and the parametrization method to rigorously enclose the traveling wave profile and the Riccati equation. We use analytic interpolation of the ODE series solution coefficients in order to establish the result for values of the dispersion parameter ranging over an interval.

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MS46

Families of Front Solutions of Modified Holling-Tanner Model with an Allee Effect

We show that within a certain parameter regime, the dynamics of a diffusive Holling-Tanner model with an Allee effect can be reduced to the bistable equation. We also show that there is a parameter regime in the system where the dynamics can be captured through the KPP equation. The existence of front solutions within these regimes and their stability will be discussed.

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MS46

Spectral Stability Via the Fredholm Determinant of a Trace Class Birman-Schwinger Operator

We propose a novel computational method to determine the spectral stability of stationary pulse solutions of nonlinear wave equations such as the cubic-quintic complex Ginzburg-Landau equation in one spatial dimension. Specifically, we show that the point spectrum of the linearization of the equation about a pulse is given by the zero set of the regular Fredholm determinant of a trace-class Birman-Schwinger operator. This operator is defined in terms of a Green's kernel for the linearized equation. We adapt a method of Bornemann to numerically approximate the Fredholm determinant by a matrix determinant, and we quantify the error in this approximation. Numerical results show excellent agreement with existing methods. The new method avoids the computational challenge of solving a stiff system for the Jost solutions that is inherent in the standard approach based on computation of the Evans function. The motivation for developing the method was for future extensions to determine the spectral stability of time-periodic pulses, for which an Evans function most likely cannot be defined.

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MS47

Extensions of the General Solution to the Inverse Problem of the Calculus of Variations

This work introduces hierarchies of Lagrangians, spanning degrees two to four, with partially determined structures influenced by leading terms and free coefficients. These coefficients adhere to the most comprehensive differential geometric criterion for Lagrangian and variational formulations, solving the inverse problem for scalar fourth-, sixth-, and eighth-order ordinary differential equations (ODEs). Notably, our Lagrangians offer increased flexibility, featuring four arbitrary functions, allowing the leading coefficient in resulting variational ODEs to be arbitrary. Previous variational representation criteria emerge as specific instances within our broader framework. The resulting variational equations, dependent on chosen leading coefficients, can represent traveling waves for various nonlinear evolution equations, some aligning with established physical models. Within specific parameter regimes, we identify families of regular and embedded solitary waves in these generalized variational ODEs, with embedded solitons confined to isolated curves within the relevant parameter space.

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MS47

Perturbative and Reversible Systems Methods for Novel Embedded Solitons of the Fkdv Equation

An earlier approach based on soliton perturbation theory is significantly generalized to obtain an analytical formula for the tail amplitudes of nonlocal solitary waves of a perturbed generalized fifth-order Korteweg-de Vries equation. On isolated curves in the (dispersion, wavespeed) parameter space, these tail amplitudes vanish, thus producing families of localized embedded solitons in large regions of the space. Off these curves, the tail amplitudes of the nonlocal waves are shown to be exponentially small in the small wavespeed limit. These seas of delocalized solitary waves, and the localized solitons embedded on the isolated curves within them, are shown to be entirely distinct from those derived in earlier work for a particular fixed value of the dispersion parameter. These perturbative results are also discussed within the framework of known reversible system results for various families of homoclinic orbits of the corresponding traveling-wave ordinary differential equation of our generalized FKdV equation, which correspond to solitary waves of the original NLPDE. In this setting too, the new families of solitary waves derived here are found to be distinct from those found in a similar earlier treatment for a specific fixed value of the dispersion parameter, and based on a different soliton solution of the unperturbed equation.

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MS47

Numerical Approximation of Rational Solutions Using Malmquist-Takenaka Functions

The numerical approximation of rational solutions to partial differential equations is often difficult using traditional methods such as Fourier, due to slow (algebraic) decay of the functions. This talk will introduce the Malmquist-Takenaka (MT) functions as a suitable basis for representing rational functions. The MT functions are set of orthogonal rational functions that, importantly, can be related to the discrete Fourier transform and computed via a modified fast Fourier transform. Several examples illustrating the effectiveness of this approach will be given, including rogue wave models.

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MS48

Localization of the Long Range Lattice Dynamics and Continuum Limit

The continuum and discrete fractional nonlinear Schrodinger equations (fDNLS) represent new models in nonlinear wave phenomena with unique properties. They model nonlocal phenomena given by differential equations with fractional derivatives. This talk surveys various aspects of localization associated to fDNLS featuring modulational instability, asymptotic construction of onsite and offsite solutions, and the role of Peierls-Nabarro barrier, which quantifies the symmetry-breaking of the translational invariance on continuous domains. Under the long range lattice interaction decaying algebraically, the phase space of solutions is infinite-dimensional unlike that of the well-studied nearest-neighbor interaction. Our focus is on the analytic and numerical study of how nonlocality and discreteness as physical parameters influence the dynamics of nonlinear dispersive phenomena. The continuum limit on a compact domain is also discussed, if time permits.

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MS49

Fokas Method for the Linearized Classical Boussinesq Initial-Boundary Value Problem with Nonzero Boundary Conditions on the Half-Line

Although initial value problems for linear evolution partial differential equations (PDEs) have been studied extensively, many open problems remain when linear evolution PDEs are instead considered in the initial-boundary value problem (IBVP) context. Furthermore, IBVPs for systems of these PDEs have been researched even less. In this presentation, we analytically solve the IBVP for the linearized classical Boussinesq system, an approximation to the Euler equations of hydrodynamics for long waves in shallow water, with nonzero boundary conditions on the half-line. Our analysis is performed through the unified transform method of Fokas, a method specifically introduced for solving linear IBVPs, which was recently extended to the solution of IBVPs for systems of linear PDEs. Specifically, we conduct our analysis in two different frameworks: (i) by exploiting the extension of Fokas's method to systems of linear PDEs; (ii) by expressing the linearized classical Boussinesq system as one higher-order equation to be solved via the usual unified transform method of Fokas. We thus establish an explicit formula that provides a novel representation for the solution to the IBVP which, thanks to its uniform convergence at the boundary, can be demonstrated via direct calculation to satisfy both the linearized classical Boussinesq system and the prescribed initial and boundary conditions.

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MS49

Small-time Limit of Complex-plane Solutions of the KdV Equation

While the KdV equation is very well studied, there is still much to learn about how singularities of KdV solutions evolve in the complex plane and how their dynamics affect the corresponding real solution on the real line. Here we apply matched asymptotic expansions in an attempt to study small-time behaviour of solutions of the KdV equation, focusing on how singularities are born at $t = 0^+$ and their initial trajectories. Results for different types of initial conditions (with different types of singularities) will be presented and discussed.

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MS50

Wandering of Coherent Structures in Stochastic Neural Fields

We study the production of waves in non-excitable cells through stochastic effects. The stochastic opening and closing of microscopic calcium channels, coupled by diffusing calcium, can lead to the production of cell-wide calcium waves. We predict the probability and dynamics of the wave using Large Deviations Theory.

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MS51

Turbulence via Intermolecular Potential

I will present a new model of turbulence in inertial gas flow at a high Reynolds number. The main difference between my model and the conventional Navier–Stokes equations is that, first, it is compatible with convection, and second, it takes into account the mean field effect of an intermolecular potential. Direct numerical simulations show that turbulence in my model emerges spontaneously from small fluctuations just like it does in nature, and the onset of turbulence depends on the Reynolds number in the same manner as in observations and experiments. Also, simple linear analysis around a constant vorticity state shows that the key variable in turbulent dynamics is the divergence of the flow velocity. At short time scales, a linear instability produces rapidly oscillating fluctuations of the velocity divergence, some of which persist along a slowly decaying eigenvector at long time scales. The Kolmogorov energy scaling is produced directly by slowly decaying fluctuations of the velocity divergence.

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MS51

Verifying Kinetic Equation in Wave Turbulence

The talk will present systems whose dynamics are governed by the nonlinear interactions among groups of 6 nonlinear waves, such as those described by the unforced quintic nonlinear Schroedinger equation. Specific parameter regimes in which ensemble-averaged dynamics of such systems with finite size are accurately described by a wave kinetic equation, as used in wave turbulence theory, are theoretically predicted. In addition, the underlying reasons that the wave kinetic equation may be a poor predictor of wave dynamics outside these regimes are also discussed. These theoretical predictions are directly verified by comparing ensemble averages of solutions to the dynamical equation with corresponding solutions of the wave kinetic equation.

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MS51

Exact Solutions of the Generalized Constantin-Lax-Majda Equation with Dissipation

We present several exact solutions of the generalized Constantin-Lax-Majda equation with dissipation $\omega_t = -au\omega_x + \omega\mathcal{H}\omega - \nu\Lambda^\sigma(\omega), u_x = \mathcal{H}\omega$, where $\widehat{\Lambda^\sigma} = |k|^\sigma$, both for the problem on the circle $x \in [-\pi, \pi]$ and the real line. We analyze these solutions from the stand point of complex pole singularities and their motion in the complex plane and find conditions for finite time collapse in these solutions for advection parameter $a = 0, 0.5$, dissipation coefficient $\nu \geq 0$ and dissipation power $\sigma = 0, 1$ values.

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MS52

Hexagon Invasion Fronts Outside the Homoclinic Snaking Region

In this talk, I will present recent numerical results on the study of localised hexagon invasion fronts that occur just outside the parameter where stationary planar hexagon fronts exist (known as the homoclinic snaking region). These invasion fronts have non-constant travelling wave speed and select a far-field spatial wavelength making them particularly difficult to compute. We show how one can use a far-field core decomposition idea to numerically set up a boundary-value problem with parameter path-following routines to investigate various bifurcations. We are then able to use these computations to compute “compatibility diagrams of two hexagon fronts that provides a heuristic wavenumber selection for hexagons in fully localised patches. We conclude with various open problems.

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MS52

The Effects of Viscosity on the Linear Stability of Damped Stokes Waves, Downshifting, and Rogue Wave Generation

We investigate a higher order nonlinear Schrödinger equation with linear damping and weak viscosity, recently proposed as a model for deep water waves exhibiting frequency downshifting. Through analysis and numerical simulations, we discuss how the viscosity affects the linear stability of the Stokes wave solution, enhances rogue wave formation, and leads to permanent downshift in the spectral peak. The novel results in this work include the analysis of the transition from the initial Benjamin-Feir instability to a predominantly oscillatory behavior, which takes place in a time interval when most rogue wave activity occurs. In addition, we propose new criteria for downshifting in the spectral peak and determine the relation between the time of permanent downshift and the location of the global minimum of the momentum and the magnitude of its second derivative.

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MT1

Vladimir Zakharov in Science of Nonlinear Phenomena

Input your abstract, including TeX commands, here. The abstract should be no longer than 1500 characters, including spaces. Only input the abstract text. Don’t include title or author information here.

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MT1

Vladimir Zakharov in Science of Nonlinear Phenomena

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MT1

Vladimir Zakharov in Science of Nonlinear Phenomena

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MT1

Vladimir Zakharov in Science of Nonlinear Phenomena

Input your abstract, including TeX commands, here. The abstract should be no longer than 1500 characters, including spaces. Only input the abstract text. Don't include title or author information here.

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MT2

An Introduction to Dispersive Hydrodynamics and Dispersive Shock Waves

Dispersive hydrodynamics is the study of multiscale nonlinear wave phenomena in dispersive media. This minitutorial will provide an introduction and overview to the field of dispersive hydrodynamics through the lens of modulation theory, the regularization of wave breaking singularities, and the formation of dispersive shock waves (DSWs). DSWs are expanding, highly oscillatory wave packets with soliton and harmonic wave limits that encompass a range of nonlinear dispersive effects. The fundamental Gurevich-Pitaevskii problem consisting of step initial conditions for the Korteweg-de Vries equation will be used as a springboard to the exploration of DSWs in a variety of settings. In this regard, the analysis of the quasi-linear, first order system of Whitham modulation equations is an effective and powerful tool for the general, practical description of DSWs. The notion of convexitystrictly hyperbolic and genuinely nonlinear modulation equationswill be presented as a conceptual framework for the classification of DSWs into types. The DSW fitting method will be used to extract macroscopic convex DSW features for integrable and non-integrable PDEs. A variety of nonclassical, nonconvex DSWs will be presented including those from equations with nonconvex hydrodynamic flux or higher order linear dispersion. The minitutorial will conclude with highlights of recent results and directions for future research.

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MT2

An Introduction to Dispersive Hydrodynamics and Dispersive Shock Waves

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MT3

Data-Driven Methods for Dynamic Systems

With the growing size of experimental data and the increase of computational power, there have been revolutionary new tools developed to model these datasets. Broadly falling under machine learning, this tutorial will review methods presented that draw inspiration from the theory of dynamical systems analysis have the power to identify reduced-order models, coherent sets, and identify variable transformations to better understand high-dimensional complex systems. These methods are firmly rooted in mathematical theory, incorporating elements of optimization, sparse regression, and neural networks, while also often having performance guarantees. The goal of this mini-tutorial is to provide an example-driven overview of how such modern computational tools can be applied to data produced by a wide variety of dynamic systems. Major components of this mini-tutorial will focus on dynamic mode decomposition, the Koopman operator and its approximation from data, and autoencoder neural networks to approximate topological conjugacies. As will be demonstrated, these methods seek to compliment, not replace, the analysis of time-dependent systems in much the same way that numerical time-stepping did in the twentieth century.

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PP1

Modeling, Optimization, and Numerical Analysis of Non-traditional Dynamical Systems With Negative Stiffness for Vibration Control of Damped Primary Structures

In this paper, a minimax optimal design of a non-conventional dynamical system with negative stiffness applied to damped primary structures is proposed to reduce high amplitudes in the resonant range of vibrations. Formulating the optimal design parameters for Dynamic Vibration Absorbers (DVAs) is a complicated task when the primary system is damped. The differential equation is formulated and the analytical solution of the system is derived. A closed-form solution for the optimal tuning coefficient is analytically obtained using the principles of Den Hartog's equal peak theory under the assumption that the structural damping ratio falls within the weak to moderate range. Subsequently, numerical determination of the optimal damping coefficient and the optimal negative stiffness parameter for the proposed non-traditional DVA with negative stiffness is achieved by solving a system of nonlinear equations formulated through the utilization of Chebyshevs equioscillation theorem. Extended simulations are conducted to examine the effectiveness of the optimally designed absorber and the sensitivity of the optimal parameters. Finally, the vibration control performance of the proposed configuration is compared with those of two typical DVAs. The comparison results demonstrate that the non-traditional DVA with negative stiffness significantly enhances vibration control by reducing the dynamic magnification response of damped primary structures and confining the normalized DAV stroke.

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PP1

Finding Integrable Structures via Machine Learning

We apply ideas of machine learning to attempt to discover the transformation to action-angle variables in a completely integrable Hamiltonian system of ordinary differential equations. As data we take the trajectories of an integrable system with (global) action-angle variables such as the open Toda flow considered by Symes. In the action-angle variables the flow takes a simple form: the actions are invariant in time, while the angles grow linearly, with growth rate determined by the action variables. The growth rates themselves are given by the gradient of a function (the Hamiltonian) with respect to the actions. These conditions on the structure are coded into objective functions to be minimized in order to allow the machine to learn these structures.

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PP1

Computing with Orthogonal Polynomials for Integrable Systems: A Riemann-Hilbert Approach

We present a numerical method for computing with orthogonal polynomials that are orthogonal on multiple, disjoint intervals. Our approach exploits the Fokas–Its–Kitaev Riemann–Hilbert representation of the orthogonal polynomials to produce an $O(N)$ method to compute the first N recurrence coefficients and allows for pointwise evaluation of the polynomials and their Cauchy integrals throughout the complex plane. Such polynomials describe the time evolution of a Toda lattice and enable a novel iterative method for solving linear systems and computing matrix functions. A similar numerical method enables the computation of large-genus solutions of the Korteweg–deVries equation.

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PP1

Asymptotic Solutions to the Steady Kp Equation and Their Dynamical Stability

The KP equation describes unidirectional fluid flow dominated either by gravity (KPII) or surface tension (KPI) in 2+1 dimensions. We use established Whitham theory for the KP equation to examine asymptotic, self-similar solutions in the steady limit, including the behavior of solitons and their interaction with rarefaction waves. In physical terms, one may think of these solutions as representing the interaction of a steady soliton with unidirectional, steady flow around an expansive corner. The soliton/rarefaction wave solutions can then be used to gain an understanding of a soliton's interaction with a dispersive shock wave, still in the steady limit. We also find good agreement of these results with numerical solutions to the KPII equation given Riemann and soliton boundary conditions; this is equivalent under certain transformations to the Riemann and soliton initial value problem for the good Boussinesq equation. However, the ultimate goal of the research is to gain an understanding of the fully dynamical KP case. We use the results for the steady case to analyze the dynamical stability of the standing wave patterns described above.

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PP1

Exponential Dichotomies in Spatial Evolutionary

Equations for Elliptic PDEs

Exponential dichotomies, when they exist, provide powerful information about the structure of bounded solutions even in the case of an ill-posed evolutionary equation. The method of spatial dynamics, in which one views a spatial variable as a time-like evolutionary variable, allows for the use of classical dynamical systems techniques, such as exponential dichotomies, in broader contexts. This has been utilized to study stationary solutions of PDEs on spatial domains with a distinguished unbounded direction (e.g. the real line or a channel). Recent work has shown how to extend the spatial dynamics framework to elliptic PDEs posed on general multi-dimensional spatial domains. In this poster we show that, in the same context, exponential dichotomies do exist, thus allowing for their use in future analyses of coherent structures, such as spatial patterns in reaction-diffusion equations on more general domains.

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PP1

Mass Transfer and Global Solutions in a Micro-Scale Model of Superfluidity

We investigate a micro-scale model of superfluidity derived by Pitaevskii in 1959 to describe the interacting dynamics between the superfluid and normal fluid phases of Helium-4. This system consists of the nonlinear Schrödinger equation and the incompressible, inhomogeneous Navier-Stokes equations, coupled to each other via a bidirectional nonlinear relaxation mechanism. The coupling permits mass/momentum/energy transfer between the phases, and accounts for the conversion of superfluid into normal fluid. We prove the existence of solutions in $\mathbb{T}^d$ $(d = 2, 3)$ for a power-type nonlinearity, beginning from small initial data. Depending upon the strength of the nonlinear self-interactions, we obtain solutions that are global or almost-global in time. The main challenge is to control the inter-phase mass transfer in order to ensure the strict positivity of the normal fluid density, while obtaining time-independent a priori estimates. We compare two different approaches: purely energy based, versus a combination of energy estimates and maximal regularity. The results in this presentation are from recent collaborations with Juhi Jang and Igor Kukavica.

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PP1

Transverse Spectral Instabilities in Rotation-Modified Kadomtsev-Petviashvili Equation and Related Models

The rotation-modified Kadomtsev-Petviashvili equation which is also known as the KadomtsevPetviashviliOstrovsky equation, describes the gradual wave field diffusion in the transverse direction to the direction of the propagation of the wave in a rotating frame of reference. This equation is a generalization of the Ostrovsky equation additionally having weak transverse effects. We investigate transverse instability and stability of small periodic traveling waves of the Ostrovsky equation with respect to either periodic or square-integrable perturbations in the direction of wave propagation and periodic perturbations in the transverse direction of motion in the rotation-modified Kadomtsev-Petviashvili equation. We also study transverse stability or instability in generalized rotation-modified KP equation by taking dispersion term as general and quadratic and cubic nonlinearity. As a consequence, we obtain transverse stability or instability in two dimensional generalization of RMBO eqution, Ostrovsky-Gardner equation, Ostrovsky-fKdV equation, Ostrovsky-mKdV equation, Ostrovsky-ILW equation, Ostrovsky-Whitham etc.

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PP1

Computing Statistics of Stochastic Differential Equations Via Tensor-Train Format

Our study explores a novel approach for computing statistics of stochastic differential equations (SDEs) without relying on Monte-Carlo sampling. By exploiting the duality of SDEs, we compute statistics via the solution of the simultaneous ordinary differential equations derived from the basis expansion of the Kolmogorov backward equation [J. Ohkubo and Y. Arai, J. Stat. Mech., 063202 (2019)]. However, when solving these equations numerically, we encounter a challenge known as the curse of dimensionality: as the dimensionality of the state space grows, the number of states increases exponentially. Addressing the curse of dimensionality, we employ the tensor-train (TT) format to efficiently solve these equations [P. Gel, S. Matera, C. Schtte, J. Comput. Phys., **314**, 489 (2016)]. The TT format enables us to compute statistics for a 50-dimensional system, surpassing the four-dimensional limit without TT format. In this poster presentation, we will discuss our approach applied to high-dimensional SDEs and the properties of the solution using the TT format.

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PP1

Transverse Modulational Dynamics of Quenched Patterns

We study transverse modulational dynamics of striped pattern formation in the wake of a directional quenching mechanism. Such mechanisms have been proposed to control pattern-forming systems and suppress defect formation in many different physical settings, such as light-sensing reaction-diffusion equations, solidification of alloys, and eutectic lamellar crystal growth. Two classical pattern-forming PDEs of interest to us are the complex Ginzburg-Landau and Swift-Hohenberg equations. We show that long-wavelength and slowly varying modulations of striped patterns are governed by a one-dimensional viscous Burgers equation, with viscous and nonlinear coefficients determined by the quenched stripe selection mechanism. This reduction to a simpler Burgers PDE allows for accurate description of defect dynamics as shock/rarefaction dynamics.

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PP1

Computing with Stones Formula: A Numerical Riemann-Hilbert Approach to the Computation of Transform Pairs

This research presents a unified methodology integrating spectral theory, Riemann-Hilbert problems, and inverse scattering theory to efficiently derive, and numerically implement, transform pairs associated to time-evolution variable-coefficient partial differential equations (PDEs). More specifically, the approach combines analytical formulae with iterative ODE and Riemann-Hilbert methods to efficiently evaluate the forward and inverse transforms, giving a hybrid analytical-numerical method for such PDEs. The method is demonstrated on transforms arising in the solution of the time-dependent Schr?dinger and Dirac equations, producing an accurate and stable time evolution method that does not require time stepping.

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PP1

Investigation of KM Breather Solutions to the Discrete Nonlinear Schrödinger Equations

The lack of integrability of the discrete nonlinear Schrödinger equation (DNLS) requires the investigation of its localized coherent structures to be performed numerically. More solutions are known for its integrable sibling, the Ablowitz-Ladik (AL) equation. One route to finding solutions to the DNLS employs the Salerno model, which interpolates between these two equations. Based on recent developments on the proximity of the AL and DNLS models, at small amplitudes we can use parametric continuation to move from the AL limit to the DNLS limit of the model to find analogous solutions [D. Henig, N. Karachalios, and J. Cuevas-Maraver, *J. Math. Phys.*, 63, 042701 (2022)]. One such solution of interest is the time-periodic Kuznetsov-Ma (KM) breathers. We identify KM solutions atop a non-constant background, prompting investigation into the existence of the breathers atop a flat background. Similar evolution of pertinent structures is demonstrated in both the AL and DNLS models for small amplitude and small breathing frequency KM breathers. We further examine the Floquet spectrums of these solutions for each model.

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PP1

Existence of Weak Solutions for the Nonlocal Klausmeier Model

We establish the existence and uniqueness of weak solutions for a nonlocal Klausmeier model within a small-time interval $[0, T)$. The Klausmeier model comprises a coupled system of nonlinear partial differential equations governing surface water and plant biomass dynamics in semiarid regions. Unlike the original model, which posits classical diffusion for plant biomass spread, we opt for a nonlocal diffusive operator in alignment with ecological field data that validates long-range dispersive behaviors of plants and seeds. The equations, defined on a finite interval in $\mathbb{R}$, feature homogeneous Dirichlet boundary conditions for the surface water equation and nonlocal Dirichlet constraints for the plant biomass equation. We assume the nonlocal operator is described by a symmetric and spatially extended convolution kernel possessing mild integrability and regularity properties. To establish existence and uniqueness, we employ the Galerkin method with a nontraditional approach. The key challenge arises from the nonlocal operator being defined on a subspace of L^2 instead of H^1, precluding the use of Aubin's compactness theorem for weak convergence of nonlinear terms. To overcome this, we introduce a new equation for the spatial derivative of plant biomass. This procedure allows us to recover enough regularity to establish compactness and complete the proof of weak convergence for the approximate solutions within the specified small-time interval $[0, T)$.

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PP1

The Riemann Problem for Spin-Orbit Coupled Bose-Einstein Condensates

Spin-orbit coupled Bose-Einstein condensates (SOC-BECs) are modelled by a coupled system of nonlinear Schrdinger (NLS) equations. This model possesses a non-convex dispersion relation, which gives rise to negative mass solutions. Khamehchi et al. (2017) proposed a scalar NLS-type model that captures the non-convex linear dispersion exactly. We study the Riemann problem for this model and find non-classical dispersive shock wave (DSW) and rarefaction wave solutions. In order to study the solutions of the Riemann problem, we use techniques based on Whitham modulation theory and the DSW fitting method. These results are verified by direct numerical solutions of the SOC-BEC and scalar models.

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PP1

Three Pieces Riemann Problem for 2-D Full Euler System in the Noble-Abel Gas

We present Riemann problem governed by 2-D full Euler system in the Noble-Abel gas. Riemann data, consisting three constants, are distributed in three distinct regions with an assumption that two adjoining regions can be connected by only one planar elementary wave. We present criteria for existence of different configurations of elementary waves for isentropic, as well as full, Euler system. We also discuss the effect of the Noble-Abel gas and the angle of regions on elementary waves and corresponding stream curves.

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PP1

Multidimensional Stability of Planar Travelling Waves for Stochastically Perturbed Reaction-Diffusion Systems

We consider reaction-diffusion systems with a multiplicative noise term, and with spatial dimension two or higher. The noise process is white in time, coloured in space, and invariant under translations (based on applications). Inspired by the works of Christian Hamster and Hermen Jan Hupkes for the one dimensional case, we prove the multidimensional stability of planar waves. We remark that the approach is similar, but not without any issues. Indeed, we end up with a mild formulation of our problem which is ill-posed in the sense of the well-understood It-integrals. To overcome the issue that we end up with integrands being anticipating, i.e., non-adapted, we exploit recent theory concerning so-called forward integrals.

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PP1

Fokas Control of the Linear KdV Equation on a Finite Interval

The Fokas method provides solutions to boundary value problems of both linear and nonlinear Lax-integrable partial differential equation. In the process a so called global relation, which connects transforms of the initial and boundary data, is exploited. Traditionally, the Fokas method is used to determine how an initial condition evolves under known boundary conditions. However, recently Kalimeris et al. (IEEE Trans. Automat. Control, 2023) developed a new numerical boundary value control algorithm for the heat equation on a finite interval, in which boundary values are constructed such that a given initial condition evolves into a null condition (i.e., null control). In this work, we develop a similar method for solving the linear Korteweg-de Vries (KdV) equation $u_t + \nu u_{xxx} = 0$. Furthermore, the method is extended beyond null control, i.e., to general final conditions.

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PP1

Stochastic Soliton Dynamics in the Korteweg-De Vries Equation with Multiplicative Noise

In recent years, stochastic traveling waves have become a major area of interest in the field of stochastic PDEs. Various approaches have been to introduced to study the effects of noise on traveling waves, mainly in the setting of Reaction-Diffusion equations. Of particular interest is the notion of a stochastic wave position and its dynamics. This poster presentation focusses on solitary waves in the Korteweg-de Vries equation. Due to a scaling symmetry, this dispersive PDE supports a solitary wave family of various amplitudes and velocities. We introduce stochastic processes that track the position and amplitude of solitons under the influence of multiplicative noise over long time-scales. Our method is based on a rescaled frame and stability properties of the solitary waves. On this poster, we showcase: - The construction of our modulation parameters following the scaling symmetry of the wave family. - An examination of stochastic soliton dynamics via direct simulation, demonstrating pathwise correspondence with our modulation parameters. - Accurate predictions for statistical properties of the wave amplitude.

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PP1

On the General Family of Third-Order Shape-Invariant Hamiltonian: Exceptional Orthogonal Polynomials Related to Generalized Hermite and Okamoto Polynomials

The rise of the inverse method and its relation to the Darboux transformation have paved the way to extend the class of known exactly solvable problems in quantum mechanics. The connection lies in the intrinsic existence of a SturmLiouville problem associated with non-relativistic and relativistic quantum systems. This allows for the spectral design of quantum systems based on an initially know solvable system, and leads to a plethora of analysis such as classification of integrable systems and the discovery of soliton-like solution to nonlinear wave phenomena. This poster reports and classifies the most general construction of rational quantum potentials in terms of the generalized Hermite and Okamoto polynomials. This is achieved by exploiting the intrinsic relation between third-order shape-invariant Hamiltonians and the -1/x, -2x, and -2x/3 hierarchies of rational solutions of the fourth Painlev equation.

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