IP0

The SIAG/Analysis of Partial Differential Equations Prize Lecture: Weak Solutions of the Euler Equations: Non-Uniqueness and Dissipation

There are two aspects of weak solutions of the incompressible Euler equations which are strikingly different to the behaviour of classical solutions. Weak solutions are not unique in general and do not have to conserve the energy. Although the relationship between these two aspects is not clear, both seem to be in vague analogy with Gromovs h-principle. In the talk I will explore this analogy in light of recent results concerning both the non-uniqueness, the search for selection criteria, as well as the dissipation anomaly and the conjecture of Onsager.

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IP1

Coupling Between Internal and Surface Waves in a Two-layers Fluid

Internal waves occur within a fluid that is stratifed by temperature or salinity variation. They are commonlygeneratedinthe oceans. They havetheform of large-amplitude, long-wavelength nonlinear waves that propagate over large distances. In some physically realistic situations, internal waves give rise to characteristic features on the surface, a signature of their presence, in the form of narrow bands of rough water, sometimes referred to as a rip, which propagates at the same velocity as the internal wave, followed after its passage, by the complete calmness of the sea, the mill pond effect. Our starting point is the two or three-dimensional Euler equations for an incompressible, irrotational fluid composed of two immiscible layers of different densities. We propose an asymptotic analysis in a scaling regime chosen to capture the observations described above. The analysis of the asymptotic model shows that the rip region of the free surface is generated by the resonant coupling between an internal soliton and the free-surface wave modes while the mill pond effect is the result of a dominant reflection coeffcient for free-surface waves in a frame of reference moving with the internal soliton

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IP2

Partial Regularity for Monge-Ampre Type Equations

Monge-Ampre type equations arise in several problems from analysis and geometry, and understanding their regularity is an important question. In particular, this kind of equations arises in the regularity theory of optimal transport maps. In the 90's Caffarelli developed a regularity theory on R^n for the classical Monge-Ampre equation, which was then extended by Ma-Trudinger-Wang and Loeper to a more general class of equations which satisfy a suitable structural condition. Unfortunately, this condition is very restrictive and it is satisfied only in very particular cases. Hence the need to develop a partial regularity theory: is it true that solutions are always smooth outside a "small" singular set? The aim of this talk is first to review the classical regularity theory, and then to describe some recent results about partial regularity.

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IP3

Waves in Honeycomb Structures

I will discuss the propagation of waves in honeycomb-structured media. The (Floquet-Bloch) dispersion relations of such structures have conical singularities which occur at the intersections of spectral bands for high-symmetry quasi-momenta. These conical singularities, also called Dirac points or diabolical points, are central to the remarkable electronic properties of graphene and the light-propagation properties in honeycomb structured dielectric media. Examples of such properties are: quasi-particles which behave as massless Dirac Fermions, tunability between conducting and insulating states and topologically protected edge states. Most theoretical work on honeycomb structures (going back to 1947) has centered on the tight-binding approximation, a solvable discrete limit corresponding to infinite medium contrast. We present results (with CL Fefferman) for the Schroedinger equation with a honeycomb lattice potential with no assumptions on medium contrast showing: a) the existence of conical singularities in dispersion surfaces for generic honeycomb lattice potentials b) the persistence of such conical singularities under perturbations which preserve time-reversal and spatial inversion symmetries, e.g. a linear strain of the honeycomb structure c) that wave-packet initial conditions, which are spectrally localized about a Dirac point are governed, on very long time-scales, by a system of homogeneous 2-dimensional Dirac equations. Finally, we discuss the question of topologically protected edge states and recent work in this direction (with CL Fefferman and J. Lee-Thorpe).

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IP4

Granular Experiments of Discrete Nonlinear Systems

Ordered and disordered arrangements of granular particles are governed by highly nonlinear contact interactions that confer to the particles assembly unique dynamic properties. We study how stress waves propagate in lattices composed of particles in close contact, and exploit this understanding to create novel materials and devices at different scales (for example, for application in energy conversion, vibration absorption and acoustic rectification). We control the constitutive behavior of these new materials selecting the particles geometry, their arrangement and materials properties. We assemble and test experimental systems and inform our experiments with discrete numerical simulations.

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IP5

Tug-of-war and Infinity Laplacian with Neumann Boundary Conditions

We study a version of the stochastic "tug-of-war" game, played on graphs and smooth domains, with an empty set of terminal states. We prove that, when the running payoff function is shifted by an appropriate constant, the values of the game after n steps converge. Using this we prove the existence of solutions to the infinity Laplace equation with vanishing Neumann boundary condition. In earlier work with Schramm, Sheffield and Wilson (http://arxiv.org/abs/math/0605002, JAMS 2009), we related a tug of war game to the infinity Laplacian equation with Dirichlet boundary conditions- I will survey that work as well as the version for the p-Laplacian in http://arxiv.org/abs/math/0607761 - Duke 2009. (Talk based on joint work with Tonci Antunovic, Scott Sheffield, Stephanie Somersille http://arxiv.org/abs/1109.4918 , Comm. PDE 2012)

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IP6

Models for Neural Networks; Analysis, Simulations and Qualitative Behavior

Neurons exchange information via discharges propagated by membrane potential which trigger firing of the many connected neurons. How to describe large networks of such neurons? How can such a network generate a collective activity? Such questions can be tackled using nonlinear partial-integro-differential equations which are classically used to describe neuronal networks. Among them, the Wilson-Cowan equations are the best known and describe globally brain spiking rates. Another classical model is the integrate-and-fire equation based on Fokker-Planck equations. The spike times distribution, which encodes more directly the neuronal information, can also be described directly thanks to structured population. We will compare and analyze these models. A striking observation is that solutions to the I&F can blow-up in finite time, a form of synchronization that can be regularized with a refractory stage. We can also show that for small or large connectivities the 'elapsed time model' leads to desynchronization. For intermediate regimes, sustained periodic activity occurs compatible with observations. A common tool is the use of the relative entropy method.

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IP7

A PDE Approach to Computing Viscosity Solutions of the Monge-Kantorovich Problem

After a quick overview of the optimal transport for the Euclidean distance problem and available numerical methods, I will present a new technique to deal with the state constraint that binds the transport when source and target have compact support. It takes the form of non-linear boundary conditions which can be combined to a Monge-Ampre equation to solve the optimal transport problem. The wide-stencil discretization technique and fast Newton solver proposed by Oberman and Froese is extended to this framework and allows to compute weak viscosity solution of the optimal transport problem. Numerical solutions will be presented to illustrate strengths and weaknesses of the method.

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IP8

Modelling Collective Cell Motion in Biology

We will consider three different examples of collective cell movement which require different modelling approaches: movement of cells in epithelial sheets, with application to rosette formation in the mouse epidermis and monoclonal conversion in intestinal crypts; cranial neural crest cell migration which requires a hybrid discrete cell-based chemotaxis model; acid-mediated cancer cell invasion, modelled via a coupled system of non-linear partial differential equations. We show that in many cases, all these models can be expressed in the framework of nonlinear diffusion equations. We show how these models can be used to understand a range of biological phenomena.

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CP1

A Comparison Analysis of q-Homotopy Analysis Method (q-HAM) and Variational Iteration Method (VIM) to Fingero Imbibition Phenomena in Double Phase Flow through Porous Media

In this paper, we consider Variational Iteration Method (VIM) and q-Homotopy Analysis Method (q-HAM) to solve the partial differential equation resulted from Fingero Imbibition phenomena in double phase flow through porous media. We further compare the results obtained here with the solution obtained in [?] using Adomian Decomposition Method. Numerical results are obtained, using Mathematica 9, to show the effectiveness of these methods on our choice of problem especially for suitable values of hand n.

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CP1

Weak Solutions to Lubrication Systems Describing the Evolution of Bilayer Thin Films

We prove existence of global non-negative weak solutions for coupled one-dimensional lubrication systems that describe the evolution of nanoscopic bilayer thin polymer films. We consider Navier-slip and no-slip conditions at both liquid-liquid and liquid-solid interfaces. Additionally, we show existence of positive smooth solutions when attractive van der Waals and repulsive Born intermolecular interactions are taken into account.

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CP1

Stability Analysis of Thin Film Problems with Non-Constant Base States

We address the linear stability of growing rims that appear in thin solid and liquid films as they retract from a solid substrate. Despite the different transport mechanisms, the mathematical models in both cases lead to mass conserving free boundary problems for degenerate and non-degenerate thin film equations of the type

$$h_t + \nabla \cdot (h^n \nabla \Delta h) = 0,$$

with different mobilities h^n. The base state is time dependent and does not have a simple traveling wave or self-similar form and thus prevents a straight forward linear stability analysis. However, large rims evolve on a slower time scale than the perturbations. We exploit this time scale separation to derive asymptotic approximations for the base states and obtain solutions of the linear stability problem. Our results enable to track the evolution of the dominant wavelength and yield criteria for the validity of the so-called "frozen modes analysis' often used for these types of problems.

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CP1

A New Mixed Formulation For a Sharp Interface Model of Stokes Flow and Moving Contact Lines

Two phase fluid flows on substrates (i.e. wetting phenomena) are important in many industrial processes, such as micro-fluidics and coating flows. These flows include additional physical effects that occur near moving (three-phase) contact lines. We present a new 2-D variational (saddle-point) formulation of a Stokesian fluid with surface tension (see Falk, Walker in the context of Hele-Shaw flow) that interacts with a rigid substrate. The model is derived by an Onsager type principle using shape differential calculus (at the sharp-interface, front-tracking level) and allows for moving contact lines and contact angle hysteresis through a variational inequality. We prove the well-posedness of the time semi-discrete and fully discrete (finite element) model and discuss error estimates. Simulation movies will be presented to illustrate the method. We conclude with some discussion of a 3-D version of the problem as well as future work on optimal control of these types of flows.

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CP2

Two-Point Riemann Problem for Inhomogeneous Nonconvex Conservation Laws: Geometric Construction of Solutions

We consider the following conservation law: $\partial_t u(x,t) + \partial_x f(u(x,t)) = g(u)$ The following boundary conditions are specified: $u(0-0,t) = u_{0-}$ and $u(X+0,t) = u_{X+}$. In addition, we specify the initial condition $u(x,0) = u_{x0}$ for $x \in (0,X)$ Method of characteristics is used to show the evolution of the initial profile and the discontinuities at the boundaries as well as appearance and in some cases disappearance of internal discontinuities. For illustration purposes the function $f(u)$ will be assumed to have 3 critical points.

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CP2

A Nonlocal Hyperbolic Pde for Chaotic Shocks

We propose a new model equation that describes chaotic shock waves. The equation is a simple modification of the Burgers equation that includes non-locality via the presence of the shock-state value of the solution in the equation itself. The model predicts steady-state solutions, their instability through Hopf bifurcation, and a sequence of period-doubling bifurcations leading to chaos. The dynamics of the solutions is qualitatively identical to those in the one-dimensional reactive Euler equations. We present a complete linear stability theory as well as nonlinear numerical simulations to characterize the observed chaotic attractor.

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CP2

A Riemann Problem at a Junction of Open Canals

We study a Riemann problem at a junction of a star-like

network of open canals. The flow in the network is given by 1D Saint-Venant equations in each canal and special conditions at the junction. We consider the case where two of the canals are identical. Firstly, we show that the linearised problem has always a unique solution. Secondly, we show that under certain condition, there is a unique solution to the nonlinear Riemann problem.

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CP2

Stability of Viscous Strong and Weak Detonation Waves for Majda's Model

We give an overview of a program based on a combination of analytical and numerical Evans-function techniques for establishing the nonlinear stability of strong and weak detonation-wave solutions of Majda's simplified, "qualitative' model for reacting mixtures of gases. One noteworthy aspect of the analysis is the treatment of weak viscous detonation waves. Due to to their nature, the stability of these undercompressive waves has received scant attention in the literature.

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CP2

Transitional Wave-Dynamics for Hyperbolic Relaxation Systems

We consider the transition between the wave dynamics of the homogeneous relaxation system and that of the local equilibrium approximation for a linearized hyperbolic relaxation system. As a specific example, we look at a Euler-type two-phase flow model with relaxation towards phase equilibrium. We observe that the stability of the transitional waves is equivalent to the sub-characteristic condition and identify the existence of a *critical region* of wave numbers where the sonic waves disappear.

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CP2

Glancing Weak Mach Reflection

We study the glancing limit of weak shock reflection, in which the wedge angle tends to zero with the Mach number fixed. Lighthill showed that, according to linearized theory, the reflected shock strength approaches zero at the triple point in reflections of this type. To understand the nonlinear structure of the solution near the triple point in nearly glancing reflections, then, it is necessary to understand how the reflected shock diffracts nonlinearly into the Mach shock as its strength approaches zero. Towards this end, we formulate a half-space initial boundary value problem for the unsteady transonic small disturbance equations that describes nearly glancing Mach reflection. We solve this IBVP numerically using high-resolution methods, and we find in the solutions a complex reflection pattern that closely resembles Guderley Mach reflection. This is joint work with John Hunter.

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CP3

Reconstruction of Nonlinear Water Waves by Generalized SfS Method

We introduce a generalized nonlinear PDE for the reflectivity function which occurs in optical reconstruction of dynamical surfaces. We use a Lambertian reflectance SfS procedure for the reconstruction of water waves. We compared the results of our numerical processing of data with experiments in the wave lab at ERAU, for different types of surface waves: linear, nonlinear, rogue, vortex induced, etc. We double check our SfS results with laser goniometry and capacitive level sensors.

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CP3

Existence and Symmetry of Ground States to the Boussinesq Abcd Systems

We consider a four-parameter family of Boussinesq systems derived by Bona-Chen-Saut. We establish the existence of the ground states which are solitary waves minimizing the action functional of the systems. We further show that in the presence of large surface tension the ground states are even up to translation.

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CP3

Sharp Thresholds of Global Existence and Blow-Up for a Class of Nonlocal Wave Equations

We first present the local and global existence and finite-time blow-up results for the nonlocal nonlinear wave equations $u_{tt} - Ku_{xx} + Mu_{tt} = g(u)_{xx}$, where K and M are two pseudo-differential operators. We then establish thresholds for global existence versus blow-up in the case of power-type nonlinearities. We use the potential well

method based on the concepts of invariant sets suggested by Payne and Sattinger. The results cover those given for the so-called double-dispersion equation and the traditional Boussinesq-type equations, as special cases. This work has been supported by the Scientific and Technological Research Council of Turkey (TUBITAK) under the project TBAG-110R002.

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CP3
Stability and Instability of Solitary Waves for a Class of Nonlocal Nonlinear Equations

We investigate the existence and stability/instability properties of solitary waves for the general class of nonlocal nonlinear wave equations $u_{tt} - Ku_{xx} + Mu_{tt} = \pm\left(|u|^{p-1}u\right)_{xx}, \quad (p > 1)$, where K and M are two pseudo-differential operators. The so-called double-dispersion equation and the Boussinesq-type equations are two well-known members of this class. The relative dominance of the two operators M and K plays an important role in our investigations. This work has been supported by the Scientific and Technological Research Council of Turkey (TUBITAK) under the project TBAG-110R002.

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CP3
On the Generalized KdV Equation

In this talk we consider the generalized Korteweg-de Vries (gKdV) equation

$$\partial_t u + \partial_x^3 u + \mu\partial_x(u^{k+1}) = 0,$$

where $k \geq 4$ is an integer number and $\mu = \pm 1$. We will review the well-posedness theory and discuss some open problems.

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CP3
Orbital Stability of Solitary Waves of Moderate Amplitude in Shallow Water

We study the orbital stability of solitary traveling wave solutions of the following equation for surface water waves of moderate amplitude in the shallow water regime:

$$u_t + u_x + 6uu_x - 6u^2u_x + 12u^3u_x + u_{xxx} - u_{xxt} + 14uu_{xxx} + 28u_xu_{xx} = 0.$$

Our approach is based on a method proposed by Grillakis, Shatah and Strauss in 1987, and relies on a reformulation of the evolution equation in Hamiltonian form. We deduce stability of solitary waves by proving the convexity of a scalar function, which is based on two nonlinear functionals that are preserved under the flow.

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CP3
Eulerian Computation Of Complex Short Wave Forms Propagating Over Long Distances

We present a new Eulerian method for computation of short waveforms over long distances using Nonlinear Solitary Waves that are solutions to the Hamilton-Jacobi equation. This method overcomes limitations of conventional discretization schemes, whose accuracy depends on grid resolution, making them too costly for real world problems. This cost can be greatly reduced by carrying the waveforms using thin pulses, which span over 4 grid cells and implicitly specifying the waveforms through initial conditions.

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CP4
On Inviscid Limits for the Stochastic Navier-Stokes Equations and Related Systems.

One of the original motivations for the development of stochastic partial differential equations traces it's origins to the study of turbulence. In particular, invariant measures provide a canonical mathematical object connecting the basic equations of fluid dynamics to the statistical properties of turbulent flows. In this talk we discuss some recent results concerning inviscid limits in this class of measures for the stochastic Navier-Stokes equations and other related systems arising in geophysical and numerical settings. This is joint work with Peter Constantin, Vladimir Sverak and Vlad Vicol.

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CP4
Rethinking Computation of Incompressible Fluid Flow More Than a Mathematical Trick

The Navier-Stokes equation is composite, orthogonally decomposable into a (dependent) pressure and a fundamental pressure-free governing equation for incompressible flow. In differential form, these involve integrals over a Greens function for the Laplacian operator, but its not immediately obvious how to solve them numerically. However, the equivalent variational forms are amenable to efficient numeric computation with a simple finite element method using discrete divergence-free velocity bases found as the curl of modified Hermite elements.

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CP4

Compressible Viscous Navier-Stokes Flows Grazing a Non-Convex Corner

I will talk about existence and regularity of solution for the compressible viscous Navier-Stokes equations on a polygon having a grazing non-convex corner. I will also talk about a jump discontinuity of the density function across a curve inside the domain and the corresponding jumps in derivatives of the velocity. The solution comes from a well-posed boundary value problem on a non-convex polygonal domain. By the decay formula of the jump it is seen that density jumps can happen in a high speed flow occuring in a very viscous compressible fluid.

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CP4

Entropy-Stable Schemes for the Initial Boundary Value Euler Equations

We consider numerical schemes for the nonlinear Euler equations of gas dynamics in one space dimension. Finite difference numerical schemes, which satisfy an entropy stability condition, have been derived and include far-field and wall boundary conditions. We have also been derived a stable numerical scheme for connecting two domains via an interface. Furthermore, we present numerical computations for second and fourth order accurate schemes to demonstrate robustness of the proposed schemes.

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CP4

Primitive Equations with Continuous Initial Data

Weaddressthewell-posednessoftheprimitiveequationsoftheoceanwithcontinuousinitial data. We show that the splitting of the initial data into a regular finite energy part and a small bounded part is preserved by the equations thus leading to existence and uniqueness of solutions.

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CP4

A Unilateral Open Boundary Condition for the Navier-Stokes Equations

One of the main issues in the simulations of blood flow in arteries is a proper setting of the outflow boundary condition at artificial boundaries. Under some physical assumptions, we propose a new approach to set the outflow boundary condition by using a variational inequality technique. Consequently, we solve the time-dependent Navier-Stokes equation with a boundary-penalty term. We report some mathematical and numerical results on this new problem, and compare it with other methods.

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CP4

Existence of Classical Sonic-Supersonic Solutions for the Steady Euler Equations

Given a smooth curve as a sonic line in the plane, we construct a classical sonic-supersonic solution on one side of the curve for the steady isentropic compressible Euler system in two space dimensions. The solution is obtained by employing an innovate coordinate system. The streamlines of the equations are analyzed to obtain a physical domain of existence.

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CP5

Multiple Steady State Solutions of Some Reaction-Diffusion Systems

We consider a class of reaction-diffusion systems leading to strongly indefinite energy functionals, with nonlinearities which combine concave and convex terms. By establishing two new critical point theorems for strongly indefinite even functionals, we obtain the existence of infinitely many large and small energy steady state solutions. Our critical point theorems generalize the fountain theorems of Barstch and Willem to strongly indefinite functionals.

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CP5

Phase Transitions with Mid-Range Interactions: a Non-Local Stefan Model

We study a non-local version of the one-phase Stefan problem which takes into account mid-range interactions, which lead to new phenomena which are not present in the usual local version of the one-phase Stefan model: creation of mushy regions, existence of waiting times during which the liquid region does not move, and possibility of melting nucleation. If the kernel is suitably rescaled, the corresponding solutions converge to the solution of the local one-phase Stefan problem.

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CP5

Stability and Convergence Analysis for Nonlocal Diffusion and Nonlocal Wave Equations

We consider the time-dependent nonlocal diffusion and nonlocal wave equations, formulated in the nonlocal peridynamics setting. Initial and boundary data are given. For nonlocal diffusion equation, the time derivatives are approximated using Forward Euler, Backward Euler and Crank–Nicholson schemes. For nonlocal wave equation, we get the dispersion relations and use the Newmark method to discretize the equation. And we use finite element method to discretize the spatial domain. For both equations, the standard timestep stability conditions must be reformulated, in light of the peridynamics formulation. We have got the the stability conditions and the convergence theorems. Computational implications verify our results.

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CP5

Localized Perturbations of the Complex Ginzburg-Landau Equation: Rcovering Fredholm Poperties Via Kondratiev Spaces

We consider perturbations to the complex Ginzburg-Landau equation in dimension 3: $A_t = (1+i\alpha)\Delta A + A - (1+i\gamma)A|A|^2 + i\epsilon g(x)A$, where $g(x)$ is a localized real valued function and ϵ is small. We are interested in finding solutions close to patterns of the form $A = e^{-i\gamma t}\bar{A}$. At $\epsilon = 0$ the linearization about the equilibrium $\bar{A}_* = 1$ is not invertible in the usual translation invariant spaces. We show that when considered as an operator between Kondratiev spaces the linearization is a Fredholm operator. These spaces consist of functions with algebraic localization that increases with each derivative. We use this result to construct solutions close to the equilibrium via the Implicit Function Theorem and derive asymptotics for wavenumbers in the far field. This is joint work with Arnd Scheel.

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CP5

Global Attractors of the Hyperbolic Relaxation of Reaction-Diffusion Equations with Dynamic Boundary Conditions

Under consideration is the hyperbolic relaxation of the semilinear reaction-diffusion equation,

$$\varepsilon u_{tt} + u_t - \Delta u + f(u) = 0,$$

$\varepsilon \in [0, 1]$, with the prescribed dynamic boundary condition,

$$\partial_{\mathbf{n}} u + u + u_t = 0.$$

For all singular and nonsingular values of the perturbation parameter, we obtain global attractors with optimal regularity. After fitting both problems into a common framework, a proof of the upper-semicontinuity of the family of global attractors is given. The result is motivated by the seminal work of J. Hale and G. Raugel in *Upper semicontinuity of the attractor for a singularly perturbed hyperbolic equation*, J. Differential Equations 73 (1988).

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CP5

On λ-Symmetry Classification and Conservations Laws of Differential Equations

We study λ-symmetry classification of nonlinear differential equations based on the fin equation. The λ-symmetry approach allows us the finding of integrating factors, the conservation forms as first integrals, similarity solutions and reducing degrees of differential equation, which is a new approach in the theory of Lie groups. We present also the theory for computing the integrating factors from λ-symmetries for a second order ordinary differential equations. Then the symmetry classifications are constructed for the different forms of heat transfer coefficient and thermal conductivity functions of the nonlinear fin equations. In addition, as a different approach the Jacobi last multiplier method is considered to determine the new forms of λ-symmetries and corresponding conservations laws and invariant solutions of the nonlinear fin equations and the results obtained from two different methods are compared in the study.

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CP6

Mathematical Analysis on Chevron Structures in Liquid Crystal Films

In this presentation, I will talk about the mathematical analysis of a model for the chevron structure arising from the cooling from the Smectic-A liquid crystal to the chiral Smectic-C phase in a surface-stabilized cell with certain boundary conditions under a given electric field. This phenomenon causes severe defects in liquid crystal display devices and has attracted interest from both theoretical and practical point of view. In the static analysis, the stability of the chevron structure is established through a sequence of minimization problems converging to a reduced energy functional based on Chen-Lubensky model. This study establishes the existence of minimizers and provides analysis of the minimal energy configuration in the limiting case.

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CP6

On the Existence of Absolute Weak Minimizers of Energy Functionals Associated with the Boundary Value Problem of Nonlinear Elasticity

In this communication, I will present a new necessary and sufficient condition for the existence of absolute weak minimizers that applies to scale-invariant energy functionals including those appearing in the pioneering work of 1982 by J. Ball on the pure displacement boundary value problem of nonlinear hyper-elastiicity. This result also brings new ideas to the regularity question associated with the boundary value problem of nonlinear hyper-elasticity that would replace the delicate phase plane analysis.

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CP6

Multicomponent Polymer Flooding in Two Dimensional Oil Reservoir Simulation

We propose a high resolution finite volume scheme for a (m+1)(m+1) system of nonstrictly hy perbolic conservation laws which models multicomponent polymer flooding in enhanced oil-recovery process in two dimensions. In the presence of gravity the flux functions need not be monotone and hence the exact Riemann problem is complicated and computationally expensive. To overcome this difficulty, we use the idea of discontinuous flux to reduce the coupled system into uncoupled system of scalar conservation laws with discontinuous coefficients. High order accurate scheme is constructed by introducing slope limiter in space variable and a strong stability preserving Runge-Kutta scheme in the time variable. The performance of the numerical scheme is presented in various situations by choosing a heavily heterogeneous hard rock type medium. Also the significance of dissolving multiple polymers in aqueous phase is presented

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CP6

A Longwave Model for Strongly Anisotropic Growth of a Crystal Step

A model of morphological evolution of a single growing crystal step is presented. Via a multi-scale expansion, we derived a long-wave, strongly nonlinear, and strongly anisotropic evolution PDE for the step profile, performed the linear stability analysis and computed the nonlinear dynamics. Linear stability depends on whether the stiffness is minimum or maximum in the direction of the step growth. It also depends nontrivially on the combination of the anisotropy strength parameter and the atomic flux from the terrace to the step. Computations show formation and coarsening of a hill-and-valley structure superimposed onto a large-wavelength profile, which independently coarsens. Coarsening laws for the hill-and-valley structure are computed for both orientations of a maximum step stiffness, the increasing anisotropy strength, and the varying atomic flux.

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CP6

Finite-Volume Numerical Approximations of Conservation Law with Fading Memory

We study the longitudinal motion of materials where the destabilizing influence of nonlinear elastic response competes with the damping effect of the fading memory. The resulting mathematical model is a system of conservation laws involving a time convolution integral. We construct, implement, and analyze a new numerical method based on the finite volume method. The implementation relies on numerical methods for advection equations with (discrete) delay. Finally we apply the complete algorithm to the elastic memory problem to make quantitatively predictions for the behaviour of the material.

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CP6

Acoustic Resonance of a Vapor Bounded by Its Own Liquid Phase

The pressure and temperature perturbations due to acoustic waves in an initially quiescent vapor in equilibrium with its liquid phase induce the evaporation and condensation at the vapor-liquid interface. The phenomenon can be mathematically formulated by a set of fluid-dynamics equations for vapor and liquid and boundary conditions at the interface. The boundary-value problem is solved and some physical features of solution for acoustic resonance involving the evaporation and condensation at the interface are discussed.

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CP7

The Robin Eigenvalue Problem for the $p(x)$-Laplacian As $p \to \infty$

We study the asymptotic behavior, as $p \to \infty$, of the first eigenvalues and the corresponding eigenfunctions for the $p(x)$-Laplacian with Robin boundary conditions in an open, bounded domain $\Omega \subset \mathbb{R}^N$ with sufficiently smooth boundary. We prove that the positive first eigenfunctions converge uniformly in Ω to a viscosity solution of a problem involving the ∞-Laplacian with appropriate boundary conditions. Joint work with F. Abdullayev (Worcester Polytechnic Institute).

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CP7

Well-Posedness of a Mathematical Model for Trace Gas Sensors

Trace gas sensors have great potential in many areas such as monitoring atmospheric pollutants, leak detection, and disease diagnosis through breath tests. We present a mathematical model of such a sensor with a modulated laser source leading to a complex system of elliptic partial differential equations. Here we present a proof of well-posedness for the resulting system of equations via the Lax-Milgram theorem as well as error estimates of the finite element method solution.

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CP7

A Unique Solution to a Quasi-Linear Elliptic Equation

We prove the existence of a unique classical solution u to the equation $-\nabla \cdot (a(u)\nabla u) + \mathbf{v} \cdot \nabla u = f$ with boundary condition $\nabla u \cdot \mathbf{n} = g$, where the value of the solution $u(\mathbf{x})$ is known at a point $\mathbf{x}_0$ in the domain. The key to proving the uniqueness of the solution is an a priori estimate for u in a Sobolev space norm.

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CP7

Eigenvalues and Eigenfunctions of the Laplacian Via Inverse Iteration with Shift

We present an iterative method, inspired by the inverse iteration with shift technique of finite linear algebra, designed to find the eigenvalues and eigenfunctions of the Laplacian with homogeneous Dirichlet boundary condition for arbitrary bounded domains $\Omega \subset \mathbb{R}^N$. Uniform convergence away from nodal surfaces is also obtained. The method can also be used in order to produce the spectral decomposition of any given function $u \in L^2(\Omega)$.

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CP7

Global Regularity for a Class of Quasi-Linear Nonlocal Elliptic Equations

We consider the solvability of quasi-linear elliptic equations with either nonlocal Neumann, Robin, or Wentzell boundary conditions, defined on bounded non-smooth domains. We develop the corresponding regularity theory for weak solutions, and show that such weak solutions are globally Hölder continuous. Several motivations, applications, and other properties are also addressed.

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CP8

Fractional Differential Equations with Impulses

In this talk we discuss fractional order impulsive differential equations. We establish existence and uniqueness of the solution using fixed point techniques. Moreover, we also apply our analytical result to fractional order model. At the end we prove the stability and perform some numerical simulation to give a pictorial view of the theoretical findings.

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CP8

Stability of Solutions of Parabolic and Hyperbolic Systems of Partial Differential Equations

The lecture is devoted to the finding of criteria of solutions stability of parabolic and hyperbolic systems of differential equations. We consider the nonlinear parabolic systems with Riemann-Liouville fractional derivatives. The technique of stability criteria finding consists of integral transformations of the considered equations into the systems of ordinary differential equations and investigation the connection between stability of the systems of ordinary differential equations and systems of parabolic equations. For the investigation of solutions stability of systems of ordinary differential equations with time-dependend coefficients we use methods given in [1]. [1] Boykov I.V. Stability of solutions of differential equations. Penza: Penza State University. 2008. 244 p.

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CP8

Exact Solutions of Nonlinear Fractional Partial Dif-

ferential Equation

Oldman and Spanier first considered the fractional diferential equations arising in diffusion problems. The fractional diferential equations have been investigated by many authors. In recent years, some effective methods for fractional calculus were appeared in open literature, such as the fractional sub-equation method and the first integral method. The fractional complex transform is the simplest approach, it is to convert the fractional diferential equations into ordinary diferential equations, making the solution procedure extremely simple. Recently, the fractional complex transform has been suggested to convert fractional order differential equations with modified Riemann-Liouville derivatives into integer order diferential equations, and the reduced equations can be solved by symbolic computation. The present paper investigates for the applicability and efficiency of the exp-function method on some fractional nonlinear diferential equations.

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CP8

Multiscaling Modelling in Evolutionary Dynamics

We study a class of processes that are akin to the Wright-Fisher model, with transition probabilities weighted in terms of the frequency-dependent fitness of the population types. By considering an approximate weak formulation of the discrete problem, we are derive a corresponding continuous weak formulation for the probability density. Therefore, we obtain a family of PDEs for the evolution of the probability density, and which will be an approximation of the discrete process in the joint large population, small time-steps and weak selection limit. The equations in this family can be purely diffusive, purely hyperbolic or of convection-diffusion type, with frequency dependent convection. The diffusive equations are of the degenerate type If the fitness functions are sufficiently regular, we can recast the weak formulation in a stronger formulation, without any boundary conditions, but supplemented by a number of conservation laws.

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CP8

A Game Theoretic Approach to Non-Relativistic Quantum Mechanics

Research into quantum foundations has led to the development of a model of NRQM based upon process theory. Processes are modeled by means of a two player, co-operative, combinatorial, forcing game, generating a discrete collection of elements embedding into a space-like hyspersurface in $\mathbb{R}^4$, evolving discretely forward in time. Each element is associated with a locally generated sinc wavelet, the NRQM wave function being the interpolation over the hypersurface. This results in a model of NRQM which is local and non-contextual at the primitive level, yet nonlocal and contextual at the process level. The structure of the game will be described.

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CP9

Numerical Methods and Multi-Scale Analysis for the Dirac Equation in Nonrelativistic Limit Regime

We compare numerically temporal/ spatial resolution of various numerical methods for solving the Dirac equation in nonrelativistic limit regime, involving a small parameter $0 < \epsilon \leq 1$ which is inversely proportional to the speed of light. In this regime, the solution is highly oscillating in time, which significantly increase the computational burden. Using the conventional finite difference methods, the time step τ requires a $\epsilon-$scalability: $\tau = O(\epsilon^3)$. Then we propose some new methods, Time Splitting Spectral(TPPS) and Exponential Wave Integrating(EWI). The new methods are unconditionally stable and their $\epsilon-$scalability are improved to $\tau = O(\epsilon^2)$. At last we provide the multi-scale method for the Dirac equation to obtain a better numerical solution.

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CP9

On the Method of Numerical Integration for Friction Boundary Conditions

Friction boundary conditions are formulated by variational inequalities of second kind, where the nonlinearity is represented by an L^1 norm on the boundary. We show that some numerical integration approximation for the L^1 norm offers nice properties such as a discrete version of complementing conditions. Applications to the Poisson, elasticity, and fluid equations are considered.

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CP9

Finite Element Analysis of the Stationary Power-Law Stokes Equations Driven by Friction Boundary Conditions

We are concern with the finite element approximation for the stationary power law Stokes equations driven by slip boundary condition of “friction type”. It is shown that by applying a variant of Babuska-Brezzi’s theory for mixed

problems, convergence of the finite element approximation formulated is achieved with classical assumptions on the regularity of the weak solution. Solution algorithm for the mixed variational problem is presented and analyzed in details. Finally, numerical simulations that validate the theoretical findings are exhibited.

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CP9

Non-Linear Controller of Combined Radiative Conduction Systems

This correspondence studies the problem of finite dimensional non-linear control for a class of systems described by nonlinear hyperbolic-parabolic coupled partial differential equations (PDEs). Initially, Galerkins method is applied to the PDE system to derive a nonlinear ordinary differential equation (ODE) system that accurately describes the dynamics of the dominant (slow) modes of the PDE system. After, we introduce a useful non linear controller to assure stabilization under convex sufficient conditions. Numerical examples show high performances.

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CP9

A Second-Order Time Discretization Scheme for a System of Nonlinear Schrödinger Equations

We propose a new time discretization scheme for a system of nonlinear Schrödinger equations which is a model of the interaction of a non-relativistic particles with different masses. Our scheme is composed of two (complex-valued) linear systems at each time step, and the solution is shown to converge at a second order rate. We report numerical example to confirm the theoretical results. Our idea can be applied to a large class of nonlinear PDEs.

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CP9

Fictitious Domain Method with the L^2-Penalty and Application to the Finite Element and Finite Volume Methods

The fictitious domain approach is useful to compute numerical solutions of PDEs defined in complex domains and time-dependent moving domains. In this paper, we study a simple fictitious domain method with L^2-penalty for elliptic and parabolic problems. A priori estimates and the error estimates for penalization problems are carefully investigated. Our methods can be applied not only to FEM but to FVM. Numerical experiments are performed to confirm the theoretical results.

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CP10

Higher Order Energy Preserving Schemes for a Nonlinear Variational Wave Equation

We consider a nonlinear variational wave equation describing the dynamics of the director field in a nematic liquid crystal. This equation has an intrinsic dichotomy between what is called conservative and dissipative solutions. Standard finite difference schemes will, generally speaking, give a dissipative solution. In this talk, we discuss how to construct higher order energy preserving numerical schemes for the nonlinear variational wave equation using the discontinuous Galerkin framework.

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CP10

Traveling Waves of Moderate Amplitude in Shallow Water

We prove existence of traveling wave solutions of an equation for surface waves of moderate amplitude arising as a shallow water approximation of the Euler equations for inviscid, incompressible and homogenous fluids. Our approach is based on techniques from dynamical systems and relies on a reformulation of the equation as an autonomous Hamiltonian system. We determine bounded orbits in the phase plane to establish existence of the corresponding periodic and solitary traveling wave solutions of elevation and depression, as well as of solitary waves with compact support. Furthermore, we provide a detailed analysis of the solitary waves' dependence on the wave speed.

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CP10

**On-Site and Off-Site Solitary Waves of the Discrete

Nonlinear Schrödinger Equation

We construct several types of symmetric localized standing waves (solitons) to the d-dimensional discrete nonlinear Schrödinger equation (dNLS) with cubic nonlinearity for $d = 1,2,3 : i\partial_t u_n = h^{-2}(\delta^2 \vec{u})_n - |u_n|^2 u_n$, where δ^2 denotes the discrete Laplacian on $\mathbb{Z}^d$, using bifurcation methods from the continuum limit. Such waves and their relative energies are thought to play a role in the propagation of localized states of dNLS across the lattice, which radiate energy until they converge to a solitary wave at a fixed lattice site. This phenomenon is known as the "Peierls-Nabarro Barrier" in discrete systems and was first investigated formally by M. Peyrard and M.D. Kruskal. These standing wave solutions and the question of their stability properties are also closely related to the variational problem of seeking critical points of the Hamiltonian subject to fixed l^2 norm (ground states).

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CP10

On a Nonlinear Dispersive Wave of Third Order

We discuss several features of a nonlinear modulated dispersive wave of third order. We show that under certain conditions, the localized smooth solution decays in time. The rate of the decay is also obtained.

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CP10

Shock-Wave Analysis of Condensate Development in a Model of Photon Scattering

We study long-time dynamics in a simplified Kompaneets equation. The Kompaneets equation describes evolution of photon energy spectrum due to Compton scattering of photons by electrons, an important energy transport mechanism in certain plasmas. For our model, we prove global existence for initial data with any finite moment, convergence to equilibrium in large time, and failure to conserve photon number for large solutions, due to formation of a shock at zero energy. This is joint work with Dave Levermore and Hailiang Liu.

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CP10

Relating Collision-Induced Dynamics of Soliton Sequences of Coupled-Nls Equations and Dynamics in Lotka-Volterra Models

We show that collision-induced dynamics of sequences of solitons of N perturbed coupled nonlinear Schrödinger (NLS) equations can be described by N dimensional Lotka-Volterra models, and that the form of the LV model depends on the nature of the perturbation term. Stability and bifurcation analysis for the equilibrium points of the LV models is used to stabilize soliton-sequence propagation and to achieve on-off switching. Furthermore, for some setups, the LV description appears to hold even outside of the perturbative regime.

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CP10

On Models of Short Pulse Type in Continuous Media

We consider ultra-short pulse propagation in nonlinear metamaterials characterized by a weak Kerr-type nonlinearity in their dielectric response. We will derive short-pulse equation (SPE) $u_{xt} = u + \frac{1}{6}(u^3)_{xx}$ in frequency band gaps. We will discuss SPE in its characteristic coordinate and the transformation to sine-Gordon equation, and robustness of various solutions emanating from the sine-Gordon equation and their periodic generalizations. By adding a regularized term in the equation, we will discuss the connection of (regularized) SPE with the nonlinear Schrodinger equation. Finally we will discuss the wellposedness of generalized Ostrovsky equation $u_{xt} = u + \frac{1}{6}(u^p)_{xx}$ with small initial data.

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CP11

Nonlocal Weighted Biological Aggregation

The Cucker-Smale flocking model has a well-known Achilles heel: the diluting effect of distant mass. A similar weakness afflicts typical nonlocal aggregation equations with attractive-repulsive interaction. To address the latter we consider a weighted-averaging approach similar to Motsch-Tadmor's adjustment of Cucker-Smale. We shall examine how gradient-flow structure is maintained via the introduction of a new metric, one that penalizes movement in crowded configurations (nonlocally). We will interpret the metric, consider its pairing with several related energy potentials under gradient flow, and discuss its influence on aggregation dynamics.

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CP11

Front-Dynamics and Pattern Selection in Semi-Bounded Domains: Pulled Vs Pushed Fronts in Cahn-Hilliard, CGL, and FHN

Invasion fronts govern pattern-forming processes in many experimental areas such as ion bombardment, chemical nucleation, and phase separation. Often, an instability is triggered spatially progressively, creating an effective boundary condition ahead of an invasion front. We describe the effect of the boundary condition on the front dynamics and the patterns in the wake. We find two basic scenarios corresponding to pushed and pulled fronts. Pushed fronts lead to oscillatory nonlinear interaction, hysteresis, and multistability in the presence of boundaries. Pulled fronts interact monotonically, with universal leading-order terms determined by absolute spectra. We prove these results, in particular establishing a complete bifurcation diagram and leagding-order asymptotics, in the complex Ginzburg Landau equation using geometric desingularization and heteroclinic matching. We also present numerical studies in Cahn-Hilliard and FitzHugh-Nagumo equations. Joint w/ A Scheel.

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CP11

Multi-Agent Control of the Generalized Viscous Burgers Equation

We model the dynamic properties of traffic flows by means of the generalized viscous Burgers equation defined over finite space. Our aim is to determine the spatio-temporal distribution of adaptive control agents for tracking the formation of traffic density patterns and for distributing the control feedback throughout the spatial domain. Feedback control is then applied to stabilize the dynamics of the Burgers equation to maximize the traffic flows or trigger finite-time transition along equilibrium profiles of the governing PDE.

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CP11

Bi-Stable Mean-Field Model

In this poster, I will present the bi-stable mean-field model to illustrate the rich long-time dynamics of stochastic models. The mathematical analysis of this model, including the study of mean-field limits, existence of multiple equilibria, and fluctuation theory was initiated by Dawson et al. Using the large-deviations theory Papanicolaou et al. recently studied the dynamical phase-transitions in such systems due to stochastic fluctuation. We consider various generalizations of such mean-field models and study the phase transitions between different equilibria in various settings.

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CP11

Different Wave Solutions Associated with Singular Lines on Phase Plane

The bifurcation phenomena of a compound K(m,m) equation are investigated in this paper. Three singular lines have been found in the associated topological vector field, which may evolve in the phase trajectories of the system. The influence of parameters as well as the singular lines on the properties of the equilibrium points has been explored in details. Transition boundaries have been obtained to divide the parameter space into regions associated with different types of phase trajectories. The existence conditions and related discussions for different traveling wave solutions have been presented in the end.

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CP12

Steklov Representations of Harmonic Functions on Exterior Regions

This talk will summarize some results about the representation of solutions of Laplace's equation in exterior regions in R^3 subject to Dirichlet, Robin or Neumann boundary data, The results generalize the theory of multipole expansions used for the region outside a ball. This is used to describe some new formulae for the electrostatic capacity of bounded sets in space. This is joint work with Qi Han.

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CP12

Differentiability of the Function Best Sobolev Constant

Let Ω be a bounded smooth domain of R^N, $1 \le p \le N$ and $p^\star := \frac{Np}{N-p}$. We consider the function $q \in [1, p^\star] \mapsto \lambda_q$, where

$$\lambda_q := \inf \left\{ \int_\Omega |\nabla u|^p \, dx : u \in W_0^{1,p}(\Omega) \quad and \quad \int_\Omega |u|^q \, dx = 1 \right\}.$$

We prove that this function is absolutely continuous and also given by the expression

$$\lambda_q = \lambda_1 \exp\left(-p \int_1^q \frac{1}{s} \int_\Omega |u_s|^s \log |u_s| \, dx ds \right)$$

for all $q \in [1, p^\star]$, where

$$u_s \in E_s := \left\{ u \in W_0^{1,p}(\Omega) : \int_\Omega |u|^s \, dx = 1 \quad and \quad \int_\Omega |\nabla u|^p \, dx = \lambda_s \right\}$$

for each $s \in [1, p^\star)$. As a consequence, λ_q is differentiable at $q \in [1, p^\star)$ if, and only if, the functional

$$I_q(u) := \int_\Omega |u_q|^q \log |u_q| \, dx$$

is constant on E_q. It follows as an application of this result that the function $q \mapsto \lambda_q$ belongs to $C^1([1, p^\star))$ if Ω is a ball. Moreover, since $q \mapsto \lambda_q$ is differentiable almost everywhere we obtain the following new observation: for almost all $q \in (p, p^\star)$ the functional I_q is constant on the set E_q.

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CP12

Bubbling Solutions for the Chern-Simons Gauged $O(3)$ Sigma Model

We construct multivortex solutions of the elliptic governing equation for the self-dual Chern-Simons gauged $O(3)$ sigma model. Our solutions show concentration phenomena at some points of the singular points as the coupling parameter tends to zero, and they are locally asymptotically radial near each blow-up point.

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CP12

A Semismooth Newton Multigrid Method for Constrained
Elliptic Optimal Control Problems

A multigrid scheme is proposed for solving the Schur complement linear systems arising in each Newton iteration when the semi-smooth Newton method is applied to solve control-constrained elliptic optimal control problems. Numerical experiments are performed to illustrate the high efficiency of our proposed method. Computation simulation show that the convergence rate is quite robust as the regularization parameter approaches to zero.

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CP12

A Free Boundary Problem for Higher Order Elliptic Operators

Let Ω be a domain in $\mathbb{R}^n$ with $0 \in \partial\Omega$. Suppose in B, the unit ball in $\mathbb{R}^n$, u and Ω satisfy the following equation in the sense of distributions:

$$Lu = \chi_\Omega \text{ in } B$$
$$nonumber \quad D^\alpha u = 0 \text{ for } |\alpha| \leq 3 \text{ in } B \setminus \Omega.$$

Here L is a homogeneous fourth order elliptic operator and χ_Ω denotes the characteristic function. We analyze the regularity properties of u.

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CP12

Numerical Solution of Nonlinear Elliptic Equation Using Finite Element Method

In this paper we have discussed the behavior, difficulties and limitations involved in solving fully nonlinear elliptic partial differential equations. Then we worked on a finite element method based on strong form of the differential equation which works well for fully nonlinear elliptic equation without much assumptions and illustrated numerical result with the help of MATLAB.

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CP13

Semicontinuous Viscosity Solutions for Quasiconvex Hamiltonians

The theory of semicontinuous viscosity solutions for convex hamiltonians introduced by Barron and Jensen in 1990 is extended to quasiconvex hamiltonians. Equations of the form $H(x, u(x), Du(x)) = 0$, with $p \mapsto H(x, r, p)$ quasiconvex, are shown to have a unique lower semicontinuous viscosity solution and such a solution is represented as the value function to a variational problem in L^∞.

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CP13

A Hamilton-Jacobi Equation for the Continuum Limit of Non-Dominated Sorting

Non-dominated sorting is a fundamental problem in multiobjective optimization, and is equivalent to several important combinatorial problems. The sorting can be viewed as arranging points in Euclidean space into fronts by repeated removal of the set of minimal elements with respect to the componentwise partial order. We prove that in the (random) large sample size limit, the fronts converge almost surely to the level sets of the viscosity solution of a Hamilton-Jacobi equation.

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CP13

General Solution to Unidimensional Hamilton-Jacobi Equation

A method for finding the general solution to the partial differential equations: $F(u_x, u_y) = 0; F(f(x)u_x, u_y) = 0 (or F(u_x, h(y)u_y) = 0)$ is presented, founded on a Legendre like transformation and a theorem for Pfaffian differential forms. As the solution obtained depends on an arbitrary function, then it is a general solution. As an extension of the method it is obtained a general solution to PDE: $F(f(x)u_x, u_y) = G(x)$,and then applied to unidimensional Hamilton-Jacobi equation.

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CP13

The Pullback Equation: An Overview

This talk will summarize some results I obtained with various authors and led to the publication of a book: [Csato-Dacorogna-Kneuss,The Pullback Equation for Differential Forms, Springer, 2012]. This equation consists of finding a map $\varphi : R^n \to R^n$ satisfying

$$\varphi^*(g) = f$$

where g and f are closed differential k-forms. This turns out to be a nonlinear first-order system of $\binom{n}{k}$ partial differential equations. I will emphasis the cases $k = 2$ and $k = n$ where we obtained global results with optimal regularity and Dirichlet condition.

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CP14

Long-time Behavior of Solutions to the Generalized Two-Component Hunter-Saxton System

We examine regularity of solutions to the non-local system

$$u_{xt} + uu_{xx} - \frac{a}{2}u_x^2 - \frac{k}{2}\rho^2 = -\frac{k}{2}\int_0^1 \rho^2 dx - \frac{a+2}{2}\int_0^1 u_x^2 dx, \qquad (1)$$

$$\rho_t + u\rho_x = a\rho u_x, \qquad (a, k) \in R^2.$$

System (1) generalizes the Hunter-Saxton equation which describes the orientation of waves in massive nematic liquid crystals. It also appears as the short-wave limit ($a = -1$, $k = \pm 1$) of the Camassa-Holm equation arising in the theory of shallow water waves, the inviscid Karman-Batchelor flow ($a = -k = 1$), the Constantin-Lax-Majda equation ($a = -k = \infty$), and the generalized Proudman-Johnson equation comprising several models from fluid dynamics. Moreover, (1) serves as a tool for studying the role that one-dimensional convection and stretching play in hydro-dynamically relevant evolution equations. In this presentation a general solution formula to (1) is derived and its regularity for a class of smooth initial data is studied.

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CP14

Boundary Value Problems of the System of Pdes of Steady Vibrations in the Theory of Thermoelasticity for Solids with Double Porosity

The boundary value problems of the system of PDEs of steady vibrations in the theory of thermoelasticity for solids with double porosity are investigated. The fundamental solution of this system is constructed by means of elementary functions. The integral representations formulas of classical solutions are presented. The basic properties of potentials are established. The uniqueness and existence theorems for boundary value problems are proved by the potential method and the theory of singular integral equations.

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CP14

From Micropolar Navier-Stokes Equations to Ferrofluids: Analysis and Numerics

The Micropolar Navier-Stokes Equations (MNSE), is a system of nonlinear parabolic partial differential equations coupling linear velocity, pressure and angular velocity, i.e.: material particles have both translational and rotational degrees of freedom. The MNSE is a central component of the Rosensweig model for ferrofluids, describing the linear velocity, angular velocity, and magnetization inside the ferrofluids, while subject to distributed magnetic forces and torques. We present the basic PDE results for the MNSE (energy estimates and existence theorems), together with a first order semi-implicit fully-discrete scheme which decouples the computation of the linear and angular velocities. Similarly, for the Rosensweig model we present the basic PDE results, together with an fully-discrete scheme combining Continuous Galerkin and Discontinuous Galerkin techniques in order to guarantee discrete energy stability. Finally, we demonstrate the capabilities of the Rosensweig model and its numerical implementation with some numerical simulations in the context of ferrofluid pumping by means of external magnetic fields.

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CP14

Damping by Heat Conduction in the Timoshenko System: Fourier and Cattaneo Are the Same

We consider the Cauchy problem of the one-dimensional Timoshenko system coupled with heat conduction, wherein the latter is described by either the Cattaneo law or the Fourier law. We prove that heat dissipation alone is sufficient to stabilize the system in both cases, so that additional mechanical damping is unnecessary. However, the decay of solutions without the mechanical damping is found to be slower than that with mechanical damping. Furthermore, in contrast to earlier results, we find that the Timoshenko-Fourier and the Timoshenko-Cattaneo systems have the same decay rate. The rate depends on a certain number, which is a function of the parameters of the system.

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MS1

Concerning the Rational Decay of Certain Fluid-Structure PDE Models

In this talk, we shall demonstrate how delicate frequency domain relations and estimates, associated with coupled systems of partial differential equation models (PDE's), may be exploited so as to establish results of uniform and rational decay. In particular, our focus will be upon decay properties of coupled PDE systems of different characteristics; e.g., hyperbolic versus parabolic characteristics. For such PDE systems of contrasting dynamics, the attainment of explicit decay rates is known to be a difficult problem, inasmuch as there has not been an established methodology to handle hyperbolic-parabolic systems. For uncoupled wave equations or uncoupled heat equations, there are specific Carleman's multiplier methods in the time domain, wherein the exponential weights in each Carleman's multiplier carefully take into account the particular dynamics involved, be it hyperbolic or parabolic. But for coupled PDE systems which involve hyperbolic dynamics interacting with parabolic dynamics, typically across some boundary interface, Carleman's multipliers are readily applicable. Given that such coupled PDE systems occur frequently in nature and in engineering applications; e.g., fluid-structure and structural acoustic interactions, there is a patent need to devise broadly implementable techniques by which one can infer uniform decay for a given PDE system. As one particular example, we shall work to conclude uniform decays for structural acoustic dynamics. In these PDE models, the structural component is subjected to a structural damping ranging from viscous (weak) to strong (Kelvin-Voight). The rational decay rates we derive for this problem explicitly reflect the extent of the damping which is in play. Since the damped elastic component of the coupled dynamics is present on only a portion of the boundary, there will necessarily be assumptions imposed upon the geometry.

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MS1

Flutter of a Cantilever Beam in Low Speed Axial Air Flow:Theory and Experi Ment

Abstract not available at time of publication.

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MS1

On a Free Boundary Fluid-Elasticity Interaction

The talk addresses the problem of minimizing turbulence inside fluid flow in the case of free boundary interaction between a viscous fluid and a moving and deforming elastic body. Our problem is motivated by the issue of reducing turbulence inside the blood flow in stenosed and stented arteries. The presentation will focus on (i) existence of an optimal control acting inside the fluid domain; and (ii) the first-order necessary conditions of optimality, which involve finding a suitable adjoint problem and using it to explicitly compute the gradient of the cost functional. This will provide the characterization of the optimal control, paving the way for a numerical study of the problem.

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MS1

Fluid-Structure Interaction with Multiple Structural Layers

We study a nonlinear, unsteady, moving boundary, fluid-structure (FSI) problem in which the structure is composed of two layers: a thin layer which is in contact with the fluid, and a thick layer which sits on top of the thin structural layer. The fluid flow, which is driven by the time-dependent dynamic pressure data, is governed by the 2D Navier-Stokes equations for an incompressible, viscous fluid, defined on a 2D cylinder. The elastodynamics of the cylinder wall is governed by the 1D linear wave equation modeling the thin structural layer, and by the 2D equations of linear elasticity modeling the thick structural layer. We prove existence of a weak solution to this nonlinear FSI problem as long as the cylinder radius is greater than zero. The spaces of weak solutions reveal a striking new feature: the presence of a thin fluid-structure interface with mass regularizes solutions of the coupled problem.

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MS2

The Stochastic Navier-Stokes Equation and the Statistical Theory of Turbulence

In 1941 Kolmogorov and Obukhov proposed that there exists a statistical theory of turbulence that allows the computation of all the statistical quantities that can be computed and measured in turbulent systems. In this talk, we will outline how to construct the Kolmogorov-Obukhov

refined scaling hypothesis (1962) with the She-Leveque intermittency corrections from the stochastic Navier-Stokes (SNS) equation. We first estimate the structure functions of turbulence and establish the Kolmogorov-Obukhov '62 scaling hypothesis with the She-Leveque intermittency corrections. Then we compute the invariant measure of turbulence writing the stochastic Navier-Stokes equation as an infinite-dimensional Ito process and solving the linear Kolmogorov-Hopf functional differential equation for the invariant measure.

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MS2

Optimal Stirring and Maximal Mixing

Passive advection of a tracer by an incompressible flow field typically results in mixing of the scalar field, an important phenomena for applications in science and engineering. Mixing may be measured via suitable norms of the tracer density, allowing for the formulation of sensible questions regarding optimal stirring strategies. In this talk we discuss current research aimed at articulating effective estimates of maximal mixing rates for specific classes of stirring flows.

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MS2

Determining Form for the 2D Navier-Stokes Equations Via Feedback Control.

Data assimilation uses a finite dimensional trajectories in a feedback control term to determine the full solution to the 2D Navier-Stokes equations. The data can be a general interpolant such as finite volume elements, nodal values, or Fourier modes. We discuss the evolution of the finite dimensional data itself, through an ordinary differential equation on a set of bounded trajectories. This is an alternative to an earlier approach which works for Fourier modes.

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MS2

Ergodic Control for Stochastic Navier-Stokes Equations

After a brief introduction to solvability and ergodic behavior of stochastic Navier-Stokes equations, the existence of optimal ergodic controls will be established for the two-dimensional stochastic Navier-Stokes equation. A controlled martingale problem with relaxed controls will provide the framework for this study. Further properties of the optimal control will be discussed.

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MS3

Spectral Stability for Transition Fronts in Multidimensional Cahn-Hilliard Systems

We consider the spectrum associated with the linear operator obtained when a Cahn-Hilliard system on $\mathbb{R}^n$ is linearized about a planar transition front solution. In the case of a single Cahn-Hilliard equation on $\mathbb{R}^n$, it's known that under general physical conditions the leading eigenvalue moves into the negative real half plane at a rate $|\xi|^3$, where ξ denotes the Fourier variable corresponding with components transverse to the wave. Moreover, in the case of a single equation, it has recently been verified that this spectral stability implies nonlinear stability. In the current analysis, we establish a framework for verifying that the spectrum for multidimensional systems follows this same cubic law, and we use this framework to show that the condition holds for certain example cases.

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MS3

Morphological Competition in Amphiphilic Systems

We present an analysis of the bifurcation and competitive evolution of co-existing morphological structures of distinct co-dimension as supported in the gradient flows of the Functionalized Cahn-Hilliard (FCH) free energy. These systems support bilayer, pore, and micelle structures, as well as complex network formed from the union of such structures. We analyse the pearling and meander instabilities of bilayer structures, and derive sharp-interface limits for the co-evolution of bilayer (homoclinic co-dimension 1) and pore (radial co-dimension 2) structures, showing that possibility of co-existence.

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MS3

Rigorous Computation of Connecting Orbits

Connecting orbits play an organizing role in dynamical systems described by partial differential equations. They describe localized patterns (pulses, boundary layers), act as building blocks for more complicated patterns, and describe the transitions between different states. The past decade has seen enormous advances in the development of computer assisted proofs in dynamics. In this talks we will discuss recent progress in the rigorous computation of connecting orbits, and directions for further research will be outlined.

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MS3

The Stability of Periodic Patterns of Localized Spots for Reaction-Diffusion Systems in R^2

We determine the spectral stability threshold for a periodic arrangment of localized spots for some singularly perturbed two-component reaction-diffusion systems including the Gierer-Meinhardt, Schnakenburg, and Gray-Scott models. In the semi-strong interaction asymptotic limit where only one of the components has an asymptotically small diffusivity, the well-known leading order stability threshold governing amplitude instabilities is independent of the lattice structure. By combining a spectral approach based on Floquet-Bloch theory together with the method of matched asymptotic expansions and appropriate Fredholm solvability condition, the next order term in the expansion of the stability threshold is calculated in terms of the regular parts of certain Green's functions. From an optimization of this term, the most stable lattice arrangement of spots is identified.

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MS4

Higher order O(N) schemes for hyperbolic problems using successive convolution

We present recent results for obtaining higher order, A-stable schemes for the wave equation. The method relies on approximating derivatives with successive applications of a certain convolution integral. The convolution stabilizes higher order schemes, and furthermore can be applied in O(N) operations using fast convolution techniques. We also briefly discuss extending the methodology to first order hyperbolic conservation laws.

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MS4

A New Discontinuous Galerkin Finite Element Method for Directly Solving the Hamilton-Jacobi Equations

In this talk, we will introduce a new discontinuous Galerkin method for solving time-dependent Hamilton-Jacobi equations. This new method works directly on the solutions, and makes use of a new entropy fix inspired by Harten and Hyman's entropy fix for Roe scheme for the conservation laws. Compared to previous works, the method has the advantage of simplicity in implementations, and could be applied to compute problems with non convex Hamiltonians.

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MS4

Optimal energy conserving local discontinuous Galerkin methods for second-order wave equation in heterogeneous media

Solving wave propagation problems within heterogeneous media has been of great interest and has a wide range of applications in physics and engineering. The design of numerical methods for such general wave propagation problems is challenging because the energy conserving property has to be incorporated in the numerical algorithms in order to minimize the phase or shape errors after long time integration. In this talk, we will discuss multi-dimensional wave problems and consider linear second-order wave equation in heterogeneous media. We will present an LDG method, in which numerical fluxes are carefully designed to maintain the energy preserving property and accuracy. We propose compatible high order energy conserving time integrators and prove the optimal error estimates and the energy conserving property for the semi-discrete methods. Our numerical experiments demonstrate optimal rates of convergence, and show that the errors of the numerical solution do not grow significantly in time due to the energy conserving property.

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MS5

Multiple Solutions to An Elliptic Problem Related to Vortex Pairs

Abstract not available at time of publication.

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MS5

Front Propagation in Isothermal Diffsuion Systems

Abstract not available at time of publication.

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MS5

Global Dynamical Analysis of An Age-Structured Cholera Model

Abstract not available at time of publication.

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MS5

A Nonlinear Problem from the Flow Between Two Counter-Rotating Disks

Abstract not available at time of publication.

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MS6

A Forward-backward Regularization of the Perona-Malik Equation

In this talk we will survey recent developments in the analysis of the Perona-Malik equation as well as related models with particular emphasis on a forward-backward regularization which turns out to be well-posed in the sense of weak Young measure solutions.

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MS6

Numerical Implementation of a New Class of Forward-backward-forward Diffusion Equations for Image Restoration

In this talk, we present the implementation and numerical experiments demonstrating new forward-backward-forward nonlinear diffusion equations for noise reduction and deblurring, developed in collaboration with Patrick Guidotti and Yunho Kim. The new models preserve and enhance the most desirable aspects of the closely-related Perona-Malik equation without allowing staircasing. By using a Krylov subspace spectral (KSS) method for time-stepping, the properties of the new models are preserved without sacrificing efficiency.

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MS6

Denoising an Image by Denoising its Curvature Image

In this work we argue that when an image is corrupted by additive noise, its curvature image is less affected by it, i.e. the PSNR of the curvature image is larger. We speculate that, given a denoising method, we may obtain better results by applying it to the curvature image and then reconstructing from it a clean image, rather than denoising the original image directly. Numerical experiments confirm this for several PDE-based and patch-based denoising algorithms.

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MS6

The Influence of Pde Based Image Processing in Analysis: Modern Developments

Abstract not available at time of publication.

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MS7

Overturning Traveling Waves in Interfacial Fluid Dynamics

Large-amplitude traveling waves in interfacial fluid dynamics can, in certain settings, be overhanging. In work with Benjamin Akers and J. Douglas Wright, we introduce a new formulation for the traveling wave problem which allows for such waves. This formulation gives a traveling wave ansatz

for a parameterized curve, making use of a normalized arclength parameterization. We apply this formulation, both analytically and computationally, to interfacial flows with surface tension.

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MS7

Low Regularity Well-posedness for the 2D Maxwell-Klein-Gordon Equation

We discuss progress on the low regularity local well-posedness for the Maxwell-Klein-Gordon equation in two dimensions.

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MS7

The Discrete Schrödinger Equation on Triangular Lattices

The discrete Schrödinger equation on a cubic lattice (in any number of dimensions) is easily solved by separation of variables. On a two-dimensional triangular lattice, however, separation of variables is not possible. The fundamental solution decays (in supremum norm) at the rate $|t|^{-3/4}$ for a generic choice of coupling coefficients between adjacent vertices. Slower power-law decay rates are observed if these coefficients satisfy a certain set of algebraic relations.

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MS7

Well-Posedness Results for a Derivative Nonlinear Schrödinger Equation

In this talk, I will discuss new results on the existence and uniqueness of solutions to a generalized derivative nonlinear Schrödinger equation. This equation, which has nonlinearity $i|u|^{2\sigma}u_x$ has recently been given some attention for its solitary wave solutions and blow up dynamics. However, there are interesting values of σ, including $1 < \sigma \leq 2$, for which no existence or uniqueness results are available. Open problems will be highlighted.

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MS8

Global Well-Posedness of Boussinesq Equations

Boussinesq equations are mathematical models of buoyancy driven flows. In this talk we first introduce the Boussinesq equations, then, we will study the global in time existence of classical solutions to some reduced 3D Boussinesq equations and also the 2D Boussinesq equations with partial dissipation.

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MS8

On the Navier-Stokes Limit of the Navier-Stokes-Voigt Equations

We consider the three-dimensional Navier-Stokes-Voigt (NSV) equations and we analyze, from the asymptotic behavior view point, its Navier-Stokes (NS) limit as the relaxation parameter vanishes. We show that the NSV-attractors converge to the weak NS-attractor in the Hausdorff semidistance induced by the weak L^2-metric on the absorbing set of the Navier-Stokes equations. Some results related to the strong topology of L^2 are also proved.

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MS8

Vortex Stretching and Sub-Criticality for the 3D Navier-Stokes Equations

The goal of this talk is to present a new approach to the problem of possible singularity formation in the 3D NSE. The first step consists of elucidating a geometric scenario leading to criticality for large data. This is based on a local, geometric measure-type regularity criterion, essentially, local, anisotropic one-dimensional sparseness of the regions of intense vorticity, coupled with the mathematical evidence that the scale of sparseness needed to prevent the blow-up may in fact be achieved via the mechanism of vortex stretching. The second step consists of attempting to brake the criticality (in the aforementioned sense/setting). Presently, this is indeed possible for a quite general class of blow-ups; in particular, for any blow-up rate featuring local spatially-algebraic structure.

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MS8

The Navier-Stokes-Voight Model for Image Inpainting

We investigate some of the advantages of the 2D Navier-Stokes-Voight (NSV) turbulence model and explore its limits in the context of image inpainting. We begin by giving a brief review of the elegant analogy between the image intensity function for the image inpainting problem and the stream function in 2D incompressible fluid, first introduced by Bertalmio et al in 2001. We show that the NSV allows for a more efficient numerical algorithm when automating the inpainting process.

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MS9

Asymptotically Preserving Scheme for Some Kinetic and Fluids Equation with Multi-Scale Behaviors

I will present some Asymptotically Preserving schemes in some kinetic and fluids equations, including low Mach fluids, a semilinear hyperbolic relaxation system with a two-scale discontinuous relaxation rate, linear kinetic equations in the diffusion limit, kinetic-fluid modeling of disperse two-phase flows, etc. I will emphasis on numerical analysis and algorithm designs for these singular and stiff problems.

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MS9

The Unified Gas Kinetic Scheme of K. Xu Applied to Linear Transport in Diffusion Regimes

I will show that the unified gas kinetic scheme (UGKS) of K. Xu et al., originally developed for gas dynamics, can be applied to a linear kinetic model of radiative transfer theory. I will show that UGKS is asymptotic preserving (AP) in both optically thick and thin regimes. Contrary to many AP schemes, this method is based on a standard finite volume approach, it does neither use any decomposition of the solution, nor staggered grids.

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MS9

High Order Semi-Implicit Runge-Kutta Finite Difference Methods and Application to Non-Linear Parabolic Relaxation Problems

We study solutions to nonlinear hyperbolic systems with fully nonlinear relaxation terms in so called diffusive limit. Suitable semi-implicit schemes based on IMEX-Runge-Kutta are constructed for the numerical solution of the relaxed limit equation. Another set of schemes is devised for relaxation systems, which are able to capture the limit diffusive relaxation with no parabolic time step restriction. A new stability analisys of the schemes is proposed and applied.

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MS9

On the Efficiency of Asymptotic Preserving Schemes

We apply the concept of Asymptotic Preserving (AP) schemes[Jin 1999] to the linearized p-system and discretize the resulting elliptic equation using continuous Finite Elements. We analyze the consistency and compare the scheme numerically with methods such as Implicit Euler. Numerical results indicate that the AP method is indeed superior to more traditional methods. We discuss extensions to higher order of consistency.

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MS10

Wave Fronts in a Model for Gasless Combustion with Heat Loss

We consider a model of gasless combustion with heat loss, where the heat loss from the system to the environment is formulated according to Newtons law of cooling. The system of partial differential equations that describe evolution of the temperature and remaining fuel contains two small parameters, a diffusion coefficient for the fuel and a heat loss parameter. We use geometric singular perturbation theory to show existence of traveling waves in this system and then study their spectral and nonlinear stability.

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MS10

Coherent Structures in a Model for Mussel-Algae Interaction

We consider a model for formation of mussel beds on soft sediments. The model consists of coupled nonlinear pdes that describe the interaction of mussel biomass on the sediment with algae in the water layer overlying the mussel bed. Both the diffusion and the advection matrices in the system are singular. We use Geometric Singular Perturbation Theory to capture nonlinear mechanisms of pattern and wave formation in this system.

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MS10

Threshold Phenomena for Symmetric Decreasing Solutions of Reaction-Diffusion Equations

We study the long time behavior of solutions of the Cauchy problem for nonlinear reaction-diffusion equations in one space dimension with the nonlinearity of bistable, ignition or monostable type. We prove a one-to-one relation between the long time behavior of the solution and the limit value of its energy for symmetric decreasing initial data in L^2 under minimal assumptions on the nonlinearities. The obtained relation allows to establish sharp threshold results between propagation and extinction for monotone families of initial data in the considered general setting.

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MS10

Traveling Waves in Coupled Reaction-Diffusion Models with Degenerate Source Terms

We consider a general system of coupled nonlinear diffusion equations that do not have isolated rest states. Such systems arise in many different applications, e.g., propagation of epidemics, ion transport in cellular matter, and evaporation and condensation in porous media. We show that the degeneracy in the source terms implies that traveling waves have a number of surprising properties that are not present for systems with nondegenerate source terms. In particular, we show that traveling wave trajectories connecting two stable rest states can exist generically only for discrete wave speeds and that families of traveling waves with a continuum of wave speeds cannot exist.

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MS11

Dispersive Estimates for Schrödinger Operators in Dimension Two

In this talk we will discuss $L^1 \to L^\infty$ dispersive estimates for Schrodinger operators in dimension two with real and decaying potentials in the case when there are no spectral assumptions at the edge of the spectrum. In addition we will describe logarithmically weighted dispersive estimates with an integrable time decay rate at infinity.

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MS11

Relaxation of Exterior Wave Maps to Harmonic Maps

We establish relaxation of arbitrary, finite energy, one-equivariant wave maps in 3 space dimensions exterior to the unit ball to the 3-sphere with a Dirichlet condition at $r = 1$, to the unique stationary harmonic map in its degree class. This settles a recent conjecture of Bizoń, Chmaj, Maliborski who proposed this problem as a model in which to study stable soliton resolution and who observed this asymptotic behavior numerically. This is joint work with C. Kenig and W. Schlag.

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MS11

A New Approach to Soliton Stability for the KdV Equation

In this work, we consider the KdV equation in the exponentially weighted spaces of Pego and Weinstein. We prove local well-posedness of the perturbation (weighted and unweighted) in the Bourgain $X^{1,b}$ space, allowing us to recreate the Pego-Weinstein result via iteration. By combining this result with the I-method, we expect ultimately to obtain soliton stability for KdV with initial data too rough to be in H^1.

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MS11

Talbot Effect for the Cubic Nonlinear Schrödinger Equation on the Torus

We study the evolution of the one dimensional periodic NLS equation with bounded variation data. For the linear evolution, it is known that for irrational times the solution is a continuous, nowhere differentiable fractal-like curve. For rational times the solution is a linear combination of finitely many translates of the initial data. We prove that a similar phenomenon occurs in the case of the cubic NLS equation.

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MS12

A Geometric Approach for Mean Curvature Motion in 2D

In this talk I will present a new approach for mean curvature motion in 2D, which explicitly connects the curve shortening from the differential geometry setting with the level set formulation, in the viscosity solutions theory. This provides an exact analytical framework for its numerical implementation, which has an important application in image processing. It runs on line on any image at http://www.ipol.im/.

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MS12

The Thin One Phase-Problem

We describe the regularity of the free boundary for the thin one-phase problem, in which the free boundary occurs on a lower dimensional subspace. This problem appears as a model of a one-phase free boundary problem in the context of the fractional Laplacian.

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MS12

On Congested Crowd Motion

We investigate the relationship between Hele-Shaw evolution with a drift and a transport equation with a drift potential, where the density is transported with a constraint on its maximum. When the drift potential is convex, the crowd density is likely to aggregate. We show that the evolving patch satisfies a Hele-Shaw type equation.

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MS12

Numerical Methods for Geometric Elliptic Partial Differential Equations

A few important geometric PDEs will be discussed which can be solved using a numerical method called Wide Stencil finite difference schemes. Focusing on the Monge-Ampere equation, I show how naive schemes can work well for smooth solutions, but break down in the singular case. There are several numerical schemes which fail to converge, or converge only in the case of smooth solutions. I will present a convergent solver which is fast, comparable to solving the Laplace equation a few times.

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MS13

Gevrey Regularity of Strongly Damped Wave Equations with Hyperbolic Dynamic Boundary Conditions

We consider a linear system of coupled PDEs which consists of a strongly damped wave equation on a bounded domain with dynamic boundary conditions governed by another wave equation (via the Laplace-Beltrami operator). We show that the system generates a strongly continuous semigroup $T(t)$ which is analytic when strong damping is present on the boundary, otherwise of Gevrey class. In both cases the flow exhibits a regularizing effect on the data. In particular, we prove quantitative time-smoothing estimates of the form $\|(d/dt)T(t)\| \leq C|t|^{-1}$ for the first case, $\|(d/dt)T(t)\| \leq C|t|^{-2}$ for the second.

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MS13

Analysis of the Ericksen-Leslie System for Liquid Crystals

In this talk we consider the Ericksen-Leslie system describing the nematic phase of liquid crystals. We discuss local and global wellposedness results for various subclasses of this system. Moreover, we present a thermodynamically consistent version of the so called simplified model. This is joint work with J. Pruss and K. Schade.

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MS13

Feedback Stabilization of Boussinesq Equations and Numerical Simulations

In this talk we present theoretical and numerical results for a feedback control problem defined by a thermal fluid. The problem is motivated by recent interest in designing and controlling energy efficient building systems. In particular, we show that it is possible to locally exponentially stabilize the nonlinear Boussinesq equations by applying finite dimensional Neumann/Robin type boundary controllers. In the end, a 2D problem is used to illustrate the ideas and demonstrate the computational algorithms.

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MS13

Well-Posedness and Small Data Global Existence for An Interface Damped Free Boundary Fluid-Structure Model

We address the well-posedness of a fluid-structure interaction model describing the motion of an elastic body immersed in an incompressible fluid. The fluid-structure system consists of the incompressible Navier-Stokes equations and a damped linear wave equation coupled through transmission boundary conditions on the free moving interface separating the elastic body and the fluid. We provide a priori estimates for the local-in-time existence of solutions for a class of initial data which also guarantees uniqueness. The global-in-time existence of solutions relies on a key energy inequality which in addition provides exponential decay of solutions of the system for given sufficiently small initial data.

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MS14

Generalized Gevrey Norms with Applications to Dissipative Equations

The regular solutions of the Navier-Stokes equations are well-known to be analytic in both space and time variables, even when one starts with non-analytic initial data. The space analyticity radius has an important physical interpretation. It demarcates the length scale below which the viscous effect dominates the (nonlinear) inertial effect. Foias and Temam introduced an effective approach to estimate space analyticity radius via the use of Gevrey norms which, since then, has become a standard tool for studying analyticity. We extend this approach to a class of dissipative equations, including critical and super-critical quasigeostrophic equations, where the dissipation operator is a fractional Laplacian. This necessitates the use of sub-analytic Gevrey classes and "generalized" Gevrey norms and development of certain commutator estimates in Gevrey classes to exploit the cancellation properties of the equation. This is achieved via the Littlewood-Paley decomposition and the Bony paraproduct formula. Though not essential for the Navier-Stokes equations, such commutator estimates become crucial for the critical and super-critical quasigeostrophic equations. Applications include large time decay of higher order derivatives.

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MS14

Bounds on Energy and Enstrophy for the 3D Navier-Stokes-α and Leray-α Models

We construct semi-integral curves which bound the projection of the global attractor of the Sabra Shell model in the plane spanned by the energy and enstrophy for the 3D regime and the plane spanned by the enstrophy and palinstrophy for the 2D regime. The semi-integral curves divide the plane into regions having limited ranges for the directions of the flow. This allows us to estimate the average time it would take a solution to burst into a region of large enstrophy and palinstrophy, respectively.

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MS14

On Inviscid Limits for the Stochastic Navier-Stokes Equations and Related Systems

One of the original motivations for the development of stochastic partial differential equations traces it's origins to the study of turbulence. In particular, invariant measures provide a canonical mathematical object connecting the basic equations of fluid dynamics to the statistical properties of turbulent flows. In this talk we discuss some recent results concerning inviscid limits in this class of measures for the stochastic Navier-Stokes equations and other related systems arising in geophysical and numerical settings. This is joint work with Peter Constantin, Vladimir Sverak and Vlad Vicol.

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MS14

Stability of Compressible Viscous Waves in a Moving Domain

We establish the sharp nonlinear stability criteria for compressible viscous surface-internal waves for two barotropic fluids near the equilibrium. The stability is characterized by the jump in the equilibrium density smaller than the critical jump value. When the lower fluid is heavier than the upper fluid, we will establish the zero surface tension limit. This is joint work with Ian Tice and Yanjin Wang.

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MS15

Nonlinearity Saturation as a Singular Perturbation of the Nonlinear Schrödinger Equation

Saturation of the Kerr nonlinearity in the nonlinear Schrödinger equation can be regarded as a singular perturbation which avoids the ill-posedness associated with the self-focusing singularity. An asymptotic expansion is presented which takes into account multiple scale behavior in both the longitudinal and transverse directions. The mechanism for interaction of solitary wave structures and an adjacent field is determined.

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MS15

Spectra of Functionalized Operators Arising from Hypersurfaces

Functionalized energies, such as the Functionalized Cahn-Hilliard, model phase separation in amphiphilic systems, in which interface production is limited by competition for surfactant phase, which wets the interface. This is in contrast to classical phase-separating energies, such as the Cahn-Hilliard, in which interfacial area is energetically penalized. In binary amphiphilic mixtures, interfaces are characterized not by single-layers, which separate domains of phase A from those of phase B via a heteroclinic connection, but by bilayers, which divide the domain of the dominant phase, A, via thin layers of phase B formed by homoclinic connections. Evaluating the second variation of the Functionalized energy at a bilayer interface yields a functionalized operator. We characterize the center-unstable spectra of functionalized operators and obtain resolvent estimates to the operators associated with gradient flows of the Functionalized energies. This is an essential step to a rigorous reduction to a sharp-interface limit.

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MS15

Spots and Stripes in NLS-type Equations with Nearly One-dimensional Potentials

We consider the existence of spots and stripes for a class of NLS-type equations in the presence of nearly one-dimensional localized potentials. Under suitable assumptions on the potential, we construct various types of waves which are localized in the direction of the potential and have single- or multi-hump, or periodic profile in the perpendicular direction. The analysis relies upon a spatial dynamics formulation of the existence problem, together with a center manifold reduction. This reduction procedure allows these waves to be realized as uni- or multi-pulse homoclinic orbits, or periodic orbits in a reduced system of ordinary differential equations.

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MS15

Stability of Line Solitons for the KP-II Equation

I will talk on nonlinear stability of line soliton solutions for the KP-II equation with respect to transverse perturbations that are exponentially localized as $x \to \infty$. The local amplitude and the phase shift of the crest of the line solitons are described by a system of 1D wave equations with diffraction terms and jumps of the local phase shift of the crest propagate in a finite speed toward $y = \pm\infty$.

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MS16

Convected Scheme Solution of the Boltzmann-Poisson System with Spectrally Accurate Phase-Space Resolution

The Boltzmann-Poisson system describes the evolution of multiple species of charged particles that interact through a self-consistent electric field and various collisional processes. Semi-Lagrangian methods like the Convected Scheme (CS) are often used to solve the transport terms, because of their ability to take large time-steps (no CFL limit) and their low numerical diffusion. The CS is mass conservative and positivity preserving, and was recently extended to arbitrarily high order of accuracy in phase-space: the new scheme was applied to the Vlasov-Poisson system on periodic domains, and validated against classical 1D-1V test-cases. Here we include a simple linear collision operator (elastic scattering) and extend the model to 1D-2V. Then we study the coupled dynamics of electrons and ions in a bounded domain.

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MS16

A High Order Time Splitting Method Based on Integral Deferred Correction for Semi-Lagrangian Vlasov Simulations

The dimensional splitting semi-Lagrangian methods with different reconstruction/interpolation strategies have been applied to kinetic simulations in various settings. However, the temporal error is dominated by the splitting error. In order to have numerical algorithms that are high order both in space and in time, we propose to use the integral deferred correction (IDC) framework to reduce the splitting error. The proposed algorithm is applied to the Vlasov-Poisson system, the guiding center model and incompressible flows.

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MS16

High Order Operator Splitting Methods Based on an Integral Deferred Correction Framework

Integral deferred correction methods have been shown to be an efficient way to achieve arbitrary high order accuracy and possess good stability properties. In this paper, we construct high order operator splitting schemes using the integral deferred correction (IDC) procedure to solve two dimensional initial-boundary-value problems. Furthermore, we present analysis which establishes that the IDC method can correct for both the splitting and numerical errors, lifting the order of accuracy by r with each correction, where r is the accuracy of the method used to solved the correction equation. Numerical examples in 2D on linear and nonlinear problems, with periodic and Dirichlet boundary conditions, are presented to demonstrate the theoretical results.

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MS16

Analysis of Optimal Superconvergence of Discontinuous Galerkin Method

We study the superconvergence of the error for the discontinuous Galerkin method for linear conservation laws. If we apply piecewise kth degree polynomials, the error between the DG solution and the exact solution is (k+2)th order superconvergent at the downwind-biased Radau points. Moreover, the DG solution is (k+2)th order superconvergent both for the cell averages and for a particular error. The idea is not based on Fourier analysis. Numerical experiments demonstrate the optimality of the superconvergence rate.

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MS17

Reduced-Order Models for Nonlinear Systems with Time-Periodic Solutions

In this talk, we discuss the use of approximate Floquet transformations to develop reduced-order models for complex flows that exhibit periodic solutions. Our strategy incorporates the proper orthogonal decomposition using sensitivity analysis and an optimal selection of subintervals for which to build snapshots. Results will include reduced-order models for Navier-Stokes and Boussinesq flows including vortex shedding and driven cavity problems.

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MS17

Reduced-Order Modeling for Adjoint Equations

Abstract not available at time of publication.

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MS17

Reduced Order Model Based on Approximated Lax Pairs

A reduced-order model algorithm, called ALP, is proposed to solve nonlinear evolution partial differential equations. It is based on approximations of Lax pairs. Contrary to other reduced-order methods, like Proper Orthogonal Decomposition, the space where the solution is searched for evolves according to a dynamics specific to the problem. It is therefore well-suited to solving problems with progressive waves or front propagation. Numerical examples are shown for the linear advection, KdV and FKPP equations, in one and two dimensions.

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MS17

Rectification Procedure for Improved Accuracy in Reduced Basis Context

Reduced basis techniques, as other model order reduction approaches use the fact that the solution of the problem we are interested in lies in a low complexity space, that, e.g. can be characterized by a small Kolmogorov n-width. A typical application frame is the solution to some parameter dependent family of PDE. In such cases, the procedure consists in computing accurately some solutions of the "low complexity space" and extrapolate in the parameter space by some approach (EIM, GEIM, Galerkin, colocation..) when the solutions is required at some other values of the parameter. In some applications, the reduced basis solution, for those parameters where an accurate solution has been computed is not equal to that approximation. An a posteriori "rectification" process can then be proposed and solve this deviation. It appears that the global solution procedure is the much improved by this rectification tool. We shall present a variety of cases where such a rectification is useful, explain the reason why it improves the accuracy and show the efficiency of this post processing action

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MS18

A Nonlocal Vector Calculus with Applications to Diffusion and Mechanics

Abstract not available at time of publication.

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MS18

Quadrature Methods in Peridynamics

Peridynamics is a nonlocal extension of classical solid mechanics suitable for modeling failure and fracture. Peridynamic models require evaluation of an integral, performed numerically by quadrature over a mesh. The domain of integration in general does not align with element edges, meaning that one must integrate over fractions of an element. In this presentation, I survey previous approaches to quadrature in peridynamics, and present a new approach for accurate 3D quadrature for peridynamics models.

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MS18

Asymptotic Behavior for Solutions in Diffusion

Models with Peridynamic-Type Nonlocality

In this talk I will present some recent results regarding the long time behavior of solutions to nonlocal wave equations with damping. These equations could appear as models in nonlocal diffusion, when one uses the Cattaneo-Vernotte flux to replace the Fourier law. Several methods suitable for this investigation will be presented, some of which are reminiscent of the local setting, and I will also point out some of the major challenges encountered in the nonlocal case.

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MS18

Origin and Effect of Nonlocality in a Composite

The purpose of this talk is to demonstrate from simple mechanical arguments that nonlocality is a basic property of heterogeneous media. By deriving a model for the smoothed displacement field in a simple composite, it is shown that nonlocality emerges naturally. The nonlocal model is put into the form of a peridynamic material model. Computations demonstrate improved agreement with experimental data on composite laminates when nonlocality is included.

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MS19

Well-posedness of the Linear KdV Equation on a Real Line

In this talk wellposedness of a linear KdV equation

$$\partial_t u + \sum_{j=0}^{3} a_j(x,t)\partial_x^j u = f$$

is investigated. This equation is a model problem, whose understanding has applications to linear and nonlinear KdV-type equations. The third derivative term ∂_x^3 makes this equation dispersive and in the non-degenerate case $a_3 \approx 1$, the wellposedness is similar to the case of $a_3 \equiv 1$. Namely wellposedness in L^2 based Sobolev spaces depends on the balance of the regularizing dispersive effect from $a_3\partial_x^3$ and the destabilizing backward heat term $a_2\partial_x^2$. This balance was investigated in [T.A., *A sharp condition for the well-posedness of the linear KdV-type equation*, (2012)]. However, when the dispersive coefficient a_3 degenerates the equation can be illposed without or despite the heat term, e.g. [Craig and Goodman, *Linear dispersive equations of Airy type*,(1990)]. The techniques that applied in the non-degenerate case can be fruitfully applied in the degenerate setting. In particular I will discuss the modified energy method for the wellposedness arguments and the geometrical optics constructions for illposedness.

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MS19

Existence and Symmetry of Ground States to a Boussinesq Abcd System

Abstract not available at time of publication.

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MS19

Coherent Frequency Dynamics for the Periodic Nonlinear Schrodinger Equation

We consider the cubic nonlinear Schrödinger equation on a periodic box. By taking an appropriate large box limit of the equation (in a spirit similar to wave turbulence theory), we derive a (new) continuum equation on $\mathbb{R}^2$, which turns out to enjoy rather surprising symmetries, stability properties, and even explicit solutions. This equation is then used (via a rigorous approximation theorem) to better understand the frequency dynamics of the original cubic NLS equation.

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MS19

Approximation of Polyatomic FPU Lattices by KdV Equations

Famously, the Korteweg-de Vries equation serves as a model for the propagation of long waves in Fermi-Pasta-Ulam (FPU) lattices. If one allows the material coefficients in the FPU lattice to vary periodically, the "classical" derivation and justification of the KdV equation go awry. By borrowing ideas from homogenization theory, we can derive and justify an appropriate KdV limit for this problem. This work is joint with Shari Moskow, Jeremy Gaison and Qimin Zhang.

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MS20

On a Stochastic Leray-Alpha Model of Euler Equations

We deal with the 3D inviscid Leray-alpha model. The well posedness for this deterministic problem is not known; by adding a random perturbation we prove that there exists a unique (in law) global solution. The random forcing term formally preserves conservation of energy. The result holds for initial velocity of finite energy and the solution has finite energy almost surely. These results are easily extended to the 2D case.

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MS20

Asymptotic Algebraic Spiral Solutions to the 2D Incompressible Euler Equations

Self similar solutions to the 2d incompressible Euler equations can exhibit spiral behavior. Classical works of Kaden, Pullin, and Moore sought out asymptotic expansions through various methods and provided conjectures for the exponents of the leading terms in these expansions. We will prove that certain classes of self-similar solutions have these asymptotic expansions and hence streamlines exhibit spiral behavior in self-similar coordinates. This is joint work with Volker Elling.

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MS20

Well-Posedness of Euler-Like Evolution Equations in Nonsmooth Domains and Relations to the Vertical Normal Modes Expansion of the Inviscid Primitive Equations

In previous joint work with C. Bardos and R. Temam, we show well-posedness of the Euler equations on a two-dimensional domain with acute corners, for weak solutions with bounded initial vorticity. This problem is an approximation, near the zero flow, to the barotropic mode of the inviscid primitive equations, that is, the zeroth mode of the vertical normal modes expansion. As a further step towards the understanding of the coupled barotropic-baroclinic system, we study the analogous approximated problem for more general background flows nearing the Brunt-Vaisala regime. The resulting system still resembles the two-dimensional Euler equation, though with non-standard boundary conditions, calling for further advancement of the elliptic theory tools developed in previous work.

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MS20

Ill-Posedness for a Class of Equations Arising in Hydrodynamics

We prove a linear ill-posedness result in L^∞ for a transport equation with a non-local (singular integral) source term. Because we only use minimal assumptions on the velocity field, we are able to prove non-linear ill-posedness results for a large class of equations arising in hydrodynamics.

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MS21

An Asymptotic-Preserving Scheme for the Semiconductor Boltzmann Equation toward the Energy-Transport Limit

We design an asymptotic-preserving scheme for the semiconductor Boltzmann equation which leads to an energy-transport system for electron mass and internal energy as mean free path goes to zero. To overcome the stiffness induced by the convection terms, we adopt an even-odd decomposition to formulate the equation into a diffusive relaxation system. New difficulty arises in the two-scale stiff collision terms, whereas the simple BGK penalization does not work well to drive the solution to the correct limit. We propose a clever variant of it by introducing a threshold on the stiffer collision term such that the evolution of the solution resembles a Hilbert expansion at the continuous level. Formal asymptotic analysis and numerical results are presented to illustrate the efficiency and accuracy of the new scheme.

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MS21

Asymptotic Preserving Scheme Based on Hyperbolic Decomposition for Compressible Euler Equations

We propose an asymptotic preserving, that is, stable and sufficiently accurate for all Mach number, central-upwind scheme for the compressible Euler equations of gas dynamics. It is well-known that the main difficulty associated with numerical simulations of such models is amplification of the numerical viscosity for small Mach numbers, which leads to a severe restriction on the size of time steps and thus substantially affects the efficiency of the method. We propose to decompose the underlying system of equations into two well-posed hyperbolic systems to remove the stiffness and thus to reduce the numerical viscosity and increase the size of time steps. The proposed discretization provides a consistent approximation of both the hyperbolic compressible regime and the elliptic incompressible regime. We conduct a number of one- and two-dimensional numerical experiments that demonstrate the asymptotic-preserving "all-speed" properties of the proposed central-upwind scheme.

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MS21

Asymptotic Preserving Imex-Type Finite Volume Methods for Some Geophysical Flows

We present new large time step methods for some hyperboli balance laws. In particular we consider the Euler equations in low Mach number limit and the shallow water flows in the low Froude number limit. In order to take into account multiscale phenomena that typically appear in geophysical flows nonlinear fluxes are split into a linear part governing the acoustic or gravitational waves and the nonlinear flow advection. We propose to approximate fast linear waves implicitly in time and in space by means of a genuinely multidimensional evolution operator. On the other hand, the nonlinear advection can be approximated explicitly in time and in space by means of the method of characteristics or some standard numerical flux function. Time integration is realized by the implicit-explicit (IMEX) method. We apply the IMEX Euler scheme, two step Runge Kutta Cranck Nicolson scheme, as well as the semi-implicit BDF scheme and prove their asymptotic preserving property in the low Mach/Froude number limits. Numerical experiments demonstrate stability, accuracy and well-balanced behaviour of these new large time step finite volume schemes with respect to small Mach/Froude numbers. This work has been done in cooperation with S. Noelle, K.R. Arun, L. Yelash and G. Bispen. Financial support of the German Science Foundation under LU 1470/2-2 is gratefully acknowledged.

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MS21

Uniform Stability and Well-balancing for Asymptotic Preserving Schemes

For a class of the splittings we formally derive asymptotic consistency and stability for IMEX discretizations of the Euler and shallow water equations. We also prove that an elliptic equation for the water surface keeps lake-at-rest solutions well-balanced.

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MS22

Existence and Qualitative Properties of Grounds States to the Non-Local Choquard-Type Equations

The Choquard equation, also known as the Hartree equation or nonlinear Schrodinger-Newton equation is a stationary nonlinear Schrodinger type equation where the nonlinearity is coupled with a nonlocal convolution term given by an attractive gravitational potential. We present sharp Liouville-type theorems on nonexistence of positive supersolutions of such equations in exterior domains. We also discuss existence, positivity, symmetry and optimal decay properties of ground state solutions under various assumptions on the decay of the external potential and the shape of the nonlinearity. In particular, we obtain a sharp decay estimate of the ground state solution which was discovered by E.Lieb in 1977. This is a joint work with Jean Van Schaftingen (Louvain-la-Neuve, Belgium)

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MS22

Dynamics of Fronts in Multistable Reaction-diffusion Equations

We study the dynamics of fronts for some reaction-diffusion equations having multi-stable reaction term. A typical example of such equations is the overdamped sine-Gordon equation. We will discuss generation of multiple fronts (with stairs-like shape), generation of metastable fronts and slow motion of fronts. This is a joint work with Toshiko Ogiwara (Josai University)

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MS22

A Local Regularity Theorem for Varifold Mean Curvature Flow

A family of k-dimensional surfaces in the n-dimensional Euclidean space or Riemannian manifold $(0 < k < n)$ is called the mean curvature flow (MCF) if the velocity of motion is equal to its mean curvature at each point and time. While most research works on the MCF are done in smooth setting, one can define and study a weak notion of MCF in the setting of varifold, known as Brakke's MCF. I will explain its definition with relevant existence results, and then explain the partial regularity theorem.

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MS22

A Reaction-Diffusion Approach to the Existence of Gravity Water Waves

While variational techniques have been successfully applied to capillary gravity water waves in order to prove existence, there are no corresponding existence proofs working in the physical/original variables in the case of zero surface tension. In this talk we will present a singular perturbation approach to the existence of two-dimensional gravity water waves, which uses the original variables.

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MS23

Focusing Quantum Many-body Dynamics: The Rigorous Derivation of the 1D Focusing Cubic Nonlinear Schrdinger Equation

We consider the dynamics of N bosons in one dimension. We derive rigorously the one dimensional focusing cubic NLS with a quadratic trap as the N tends to infinity limit of the N-body dynamic and hence justify the mean-field limit and prove the propagation of chaos for the focusing quantum many-body system.

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MS23

Local Well-posedness of KdV with Potential

We prove local well-posedness of the Korteweg-de Vries (KdV) equation on the line with potential

$$\partial_t u = \partial_x(-\partial_x^2 u - 3u^2 + Vu)$$

in $H^1(\mathbb{R})$. This is achieved by introducing a suitable parametrix approximation to the linear propagator, and then proving local smoothing and maximal function estimates for this parametrix analogous to those obtained in the free case by [C.E. Kenig, G. Ponce, and L. Vega, Well-posedness of the initial value problem for the Korteweg-de Vries equation, J. Amer. Math. Soc. 4 (1991), no. 2, pp. 323–347.] Global well-posedness follows easily from the energy. This equation arises as a model of shallow water wave propagation in a channel over a bottom of varying depth, and the $H^1(\mathbb{R})$ well-posedness is needed in the study of soliton dynamics.

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MS23

Scattering for Nonlinear Schrödinger Equation with a Potential

We study global well-posedness and scattering for a 3d cubic focusing nonlinear Schrödinger equation

$$iu_t + \Delta u - Vu + |u|^2 u = 0;\ u(0) = u_0 \in H^1,$$

where V is a real-valued short-range potential with a small negative part. First, we find criteria for global well-posedness from the maximization problem related to the Gagliardo-Nirenberg inequality. Next, we investigate scattering of such global solutions. Following Kenig-Merle's program, we prove that (1) if there are non-scattering solutions obeying the criteria, then there exists a special counterexample, namely a *minimal blow-up solution*; (2) if we further assume that a potential is repulsive, this counterexample does not exist, and the criteria for global well-posedness thus imply scattering.

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MS23

The Gross-Pitaevskii Hierarchy on the Three-dimensional Torus

In this talk, we will study the Gross-Pitaevskii hierarchy on the spatial domain $\mathbb{T}^3$. In the first part of the talk, we will prove a conditional uniqueness result for the hierarchy. As a result of our analysis, we will obtain a sharp range of integrability exponents in the key spacetime estimate. In the second part of the talk, we will add randomness into the problem by randomizing the collision operators on the Fourier domain. In this randomized setting, we will study the limiting behavior of Duhamel iteration terms. The first part is based on joint work with Philip Gressman and Gigliola Staffilani. The second part is based on joint work with Gigliola Staffilani.

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MS24

Geometric Partial Differential Equations in Random Media

We present some results on the geometry and regularity of some geometric variational problems in random media. As for the stationary problem, we study area minimizers with random boundary condition, with focus on the Plateau Problem. For the evolutionary case, we consider a mean curvature evolution in random media and related problems that model population growth and phase transitions in random media.

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MS24

Stochastic Homogenization for Porous Medium Type Equations

In a recent paper, Ambrosio, Frid, and Silva study the homogenization problem for a class of porous-medium type equations where the flux function is a stationary random process on a compact probability space. We extend their result to the general stochastic framework, removing the compactness assumption on the probability space. Passing from the small to the large scale, we show the convergence in probability of the weak solutions of rescaled problem to the weak solution of an homogenized deterministic porous-medium type equation.

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MS24

Boundary Regularity for a Class of Degenerate Monge-Ampere Equations

We discuss boundary regularity for the Monge-Ampere equation when the right hand side behaves as a positive power of the distance function near the boundary of the domain. As a consequence we obtain global C^2 estimates of the eigenfunction for the Monge-Ampere equation. Similar results were obtained in 2D by J.X. Hong, G. Huang, W. Wang.

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MS24

A New PDE Approach for Large Time Behavior of Hamilton-Jacobi Equations

I will present a new PDE approach to obtain large time behavior of Hamilton- Jacobi equations. This applies to usual Hamilton-Jacobi equations, as well as the degenerate viscous cases, and weakly coupled systems. The degenerate viscous case was an open problem in last 15 years.

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MS25

Uniform Stability of a Fluid-Structure Interaction with Interface and Interior Controls in the Fluid Inside Structure Setting

We consider the uniform stability of *finite energy solutions* to a nonlinear fluid-structure interaction model in a bounded domain $\Omega \in \mathbf{R}^2$. In this model, Ω is occupied by two environments: fluid and solid, with fluid flown inside the solid. The interaction occurs at the static interface. If an interior viscous nonlinear damping is placed on the solid, the energy of the overall system decays to zero at a uniform rate. If additional boundary damping is placed on the interface and a geometric condition is satisfied, the energy decays at an exponential rate.

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MS25

Nonlinear Stability for Fluid-Structure Interaction Models

The classical one-phase Stefan problem models the temperature distribution in a homogeneous medium undergoing a phase transition, such as ice melting to water. This is accomplished by solving the heat equation on a time-dependent domain whose free-boundary is transported by the normal derivative of the temperature along the evolving and a priori unknown free-boundary. We establish a global-in-time stability result for small temperatures, using a novel hybrid methodology, which combines energy estimates inspired by the Euler equations, decay estimates, and Hopf-type inequalities. This is joint work with M. Hadzic.

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MS25

Shape Optimization with Nonlinear PDE Constraints. Compressible Navier-Stokes Equations

Abstrat not available at time of publication.

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MS25

Stability Analysis of Fluid-structure Interaction Models

We consider an established fluid-structure interaction model. We present recent joint results on polynomial/rational decay which are obtained as an interplay of functional analytic techniques, PDE estimates, and microlocal analysis, to obtain the optimal parameter of decay.

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MS26

Vortex Sheets in Domains with Boundaries

This talk concerns the interaction of incompressible 2D flows with compact material boundaries under vortex sheet regularity. We focus on the dynamic behavior of the circulation of velocity around boundary components and the possible exchange between flow vorticity and boundary circulation in flows with vortex sheet initial data. We recast 2D Euler evolution using vorticity and the circulation (around boundary components) as dynamic variables and provide a weak formulation. Our main results are the equivalence between the weak velocity and weak vorticity formulations of the 2D Euler equations on domains with boundary and a criterion for computing the resulting force on boundary components for flows with little regularity.

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MS26

Mathematical Models of Intermittency in Fully Developed Turbulence

Physical models of intermittency in fully developed turbulence use many phenomenological concepts such as active volume, region, eddy, energy accumulation set, etc, used to de- scribe non-uniformity of the energy cascade. In this talk we give these terms a precise mathematical meaning in the language of the Littlewood-Paley analysis. With our definitions we establish some of the deterministic counterparts of the classical scaling laws for the energy spectrum and second order structure function with proper intermittency correction.

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MS26

Inviscid Limit for Invariant Measures of the 2D Stochastic Navier-Stokes Equations

We discuss recent results on the behavior in the infinite Reynolds number limit of invariant measures for the 2D stochastic Navier-Stokes equations. We prove that the limiting measures are supported on bounded vorticity solutions of the 2D Euler equations. Invariant measures provide a canonical object which can be used to link the fluids equations to the heuristic statistical theories of turbulent flow.

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MS26

Non-Uniqueness Phenomena for Weak Solutions of the Euler Equations

It has been known since V. Scheffer's groundbreaking work twenty years ago that the Cauchy problem for the incompressible Euler equations admits non-unique weak solutions with highly pathological behaviour. I will survey various recent results on such "wild solutions" and discuss conceivable uniqueness criteria.

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MS27

Stationary Co-Dimension One Structures in the Functionalized Cahn-Hilliard Model

The functionalized Cahn-Hilliard energy models interfacial energy in amphiphilic phase separated mixtures. Its minimizers encompass a rich class of morphologies with detailed inner structure, including bilayers, pore networks, pearled pores, and micelles. We address the existence and stability of a class of single-curvature bilayer structures in $d > 1$ space-dimensions. The existence problem involves the construction of homoclinic solutions in a perturbed 4th-order Hamiltonian system. The linear stability involves an analysis of meander and pearling modes.

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MS27

Existence and Stability of Solutions in the Multidimensional Swift–Hohenberg Equation

The existence of stationary localized spots for the planar and the three-dimensional Swift–Hohenberg equation is proved using geometric blow-up techniques. The spots have a much larger amplitude than that expected from a formal scaling in the far field. One advantage of the geometric blow-up methods is that the anticipated amplitude scaling does not enter as an assumption into the analysis but emerges during the construction. The stability of these solutions will also be addressed.

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MS27

Pattern Selection in the Wake of Fronts

Motivated by the formation of complex patterns in the wake of growth processes in bacterial colonies, we'll study more generally patterns formed in the wake of moving fronts. We discuss a number of mathematical problems that arise when one tries to predict which wavenumbers and what type of pattern is created by the growth process. We therefore describe in some detail how to derive linear predictions and analyze nonlinear mechanisms that lead to failure of these predictions. This is joint work with Matt Holzer and Ryan Goh.

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MS27

Small-amplitude Grain Boundaries of Arbitrary Angle in the Swift-Hohenberg Equation

We study grain boundaries in the Swift-Hohenberg equation. Grain boundaries arise as stationary interfaces between roll solutions of different orientations. Our analysis shows that such stationary interfaces exist near onset of instability for *arbitrary* angle between the roll solutions.

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MS28

Global Existence for Water Wave Equations

Abstract not available at time of publication.

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MS28

A Boundary Perturbation Method for Reconstruction of Layered Media via Constrained Quadratic Optimization

The scattering of linear waves by layered media constitute a fundamental model in oceanography, acoustics, electromagnetics, and the geosciences. In this talk we examine the problem of detecting the geometric properties of a two-dimensional acoustic medium where the fields are governed by the Helmholtz equation. Building upon the success of our previous Boundary Perturbation approach (implemented with the Operator Expansions formalism) we derive a new approach which augments this with a new "smoothing" mechanism. With numerous numerical experiments we demonstrate the enhanced stability and accuracy of our new approach which further suggests not only a rigorous proof of convergence, but also a path to generalizing the algorithm to multiple layers, three dimensions, and the full equations of linear elasticity and Maxwell's equations.

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MS28

Global Existence for Gravity Waves in 2 Dimension

We consider the water waves system for the evolution of a perfect fluid with a free surface in 2d, under the influence of gravity. For sufficiently smooth and localized initial data we prove global existence of small solutions. We also prove asymptotics for such solutions, showing a nonlinear behavior as time goes to infinity. This is joint work with A. Ionescu.

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MS28

On the Finite-time Splash and Splat Singularities for the 3-D Free-surface Euler Equations

e prove that the 3-D free-surface incompressible Euler equations with regular initial geometries and velocity fields have solutions which can form a finite-time splash (or splat) singularity, wherein the evolving 2-D surface, the moving boundary of the fluid domain, self-intersects at a point (or on surface). Such singularities can occur when the crest of a breaking wave falls unto its trough, or in the study of drop impact upon liquid surfaces. Our approach is founded upon the Lagrangian description of the free-boundary problem, combined with a novel approximation scheme of a finite collection of local coordinate charts; as such we are able to analyze a rather general set of geometries for the evolving 2-D free-surface of the fluid.

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MS29

On the Bound of DG and Central DG Operators

Discontinuous Galerkin (DG) and central DG methods are two families of high order methods, and it was observed that the latter allows larger time steps in stable numerical simulation especially when the accuracy is relatively high. In this paper, we estimate the bounds of DG and central DG spatial operators for linear advection equation. Based on such estimates and Kreiss-Wu theory, time step conditions are obtained to ensure numerical stability when the methods are coupled with locally stable time discretizations. In particular, with a fixed time discretization, the time step grows quadratically with k when the DG method is used in space (here k is the polynomial degree of the discrete space), while in the case of the central DG method, the dependence of the time step on k is linear. In addition, the analysis provides new insight into the role of a parameter in the central DG formulation. We verify our results numerically, and also discuss the extension of the analysis to some related discretiztions.

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MS29

High-order Multiderivative Time Integrators for

Hyperbolic Conservation Laws

Time stepping methods for hyperbolic conservation laws often fall into one of two distinct categories: a method of lines formulation, and a single-step Taylor (Lax-Wendroff) formulation. The existence of so-called multiderivative time integrators for ordinary differnetial equations indicate that this is indeed a false dichotomy. In fact, multiderivative methods have a long history of development for ordinary differential equations dating back to at least the 1950's. However, only the extreme versions of these methods have been explored as a numerical tool for solving partial differential equations. In this work, we demonstrate that explicit Runge-Kutta methods as well as high-order Taylor (Lax-Wendroff) methods are special cases of multiderivative methods, and in addition, we demonstrate how these methods can be applied for solving hyperbolic conservation laws using the weighted essentially non-oscillatory (WENO) method, as well as the discontinuous Galerkin (DG) method.

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MS29
A High Order Weno Scheme for Detonation Waves

Abstract not available at time of publication.

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MS29
Asymptotic Preserving Discontinuous Galerkin Method for the Radiative Transfer Equation

Many kinetic equations converge to macroscopic models, known as the asymptotic limit of the kinetic equations, when ϵ (the ratio of mean free path over macroscopic size) $- > 0$. Asymptotic preserving (AP) methods are designed to preserve the asymptotic limits from microscopic to macroscopic models in the discrete setting. In the asymptotic regimes (when $\epsilon <<0$) , they become a consistent discretization of the macroscopic solvers automatically, while remain microscopic otherwise. In this presentation, we consider the radiative transfer equation which models isotropic particle scattering in a medium. Many finite volume (FV) methods do not have the AP property. Discontinuous Galerkin (DG) (with upwind flux and at least piecewise linear polynomial) methods are known to have such property, but require much more degree of freedom, especially in high dimensional applications. We will present an AP mixed DG-FV method which has comparable computational cost and memory as FV method. Rigorous analysis will be provided to show that the proposed methods are consistent with the limit equation in the asymptotic regimes. Some numerical examples are presented to demonstrate the performance of our methods.

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MS30
Conditioning of Nonlocal Operators in Fractional Sobolev Spaces

We study the conditioning of the weak from of the nonlocal operator associated to nonlocal diffusion and peridynamics in fractional Sobolev spaces. For both maximal and minimal eigenvalues, we provide sharp estimates which involve explicit quantifications of the horizon, mesh size, and the regularity of the fractional Sobolev space. For these estimates, we use an interesting combination of tools from functional analysis and numerical linear algebra. The sharpness results are also supported with numerical experiments.

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MS30
Adaptive Numerical Methods for Periydnamics

Abstract not available at time of publication.

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MS30
Differentiability for Solutions of Nonlocal Models with Weakly Singular Kernels

Abstract not available at time of publication.

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MS30
Surface Effects and Affects on Ordinary Isotropic Peridynamics Models

Abstract not available at time of publication.

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MS31
Acoustic Propagation in a Saturated Piezo-Elastic, Porous Medium

We study the problem of derivation of an effective model of acoustic wave propagation in a two-phase, non-periodic medium modeling a fine mixture of linear piezo-elastic solid

and a viscous Newtonian, ionic bearing fluid. Bone tissue is an important example of a composite material that can be modeled in this fashion. We develop two-scale homogenization methods for this system, and discuss also a stationary random, scale-separated microstructure. The ratio e of the macroscopic length scale and a typical size of the microstructural inhomogeneity is a small parameter of the problem. Another possibly small parameter is the Peclet number which in?uences the type of e?ective equations which are obtained.

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MS31

Homogenization of Rigid Suspensions with Highly Oscillatory Velocity-Dependent Surface Forces

We study particulate flows or suspensions of solid particles in a viscous incompressible fluid at the presence of highly oscillatory surface forces. The flow at a small Reynolds number is modeled by the Stokes equations coupled with the motion of absolutely rigid particles arranged in a periodic array. The objective is to perform homogenization for the given suspension and obtain an equivalent description of a homogeneous (effective) medium whose viscosity is determined using the analysis on a periodicity cell. Mathematical tools that the main technical construct is built upon are based on Γ-convergence theory.

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MS31

Nonlinear Neutral Inclusions: Assemblages of Spheres and Confocal Coated Ellipsoids

If a neutral inclusion is inserted in a matrix containing a uniform applied electric field, it does not disturb the field outside the inclusion. The well known Hashin coated sphere is an example of a neutral coated inclusion. In this talk, we consider the problem of constructing neutral inclusions from nonlinear materials. In particular, we discuss assemblages of coated spheres and ellipsoids.

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MS31

Dynamic Brittle Fracture as a Small Horizon Limit of Peridynamics

We consider peridynamic formulations with unstable constitutive laws that soften beyond a critical stretch. Here we discover new quantitative and qualitative information that is extracted from the peridynamic formulation using scaling arguments and by passing to a distinguished small horizon limit. In this limit the dynamics correspond to the simultaneous evolution of elastic displacement and fracture. The displacement fields are shown to satisfy the wave equation. The wave equation provides the dynamic coupling between elastic waves and the evolving fracture path inside the media. The limit evolutions have bounded energy expressed in terms of the bulk and surface energies of brittle fracture mechanics.

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MS32

On the Well-Posedness of the 3D Navier-Stokes Equations in the Largest Critical Space

In this talk I will discuss various well-posedness and ill-posedness results for the 3D Navier-Stokes equations in the largest critical space. In particular, I will describe a recent norm inflation result for the hyperdissipative Navier-Stokes equations that occurs in critical and supercritical spaces even in the case where the global regularity is known. We will see how a new non-critical scaling becomes an obstacle in proving small initial data results in critical spaces.

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MS32

Initial-Boundary Layer in the Nonlinear Darcy-Brinkman System

We study the interaction of initial layer and boundary layer in the nonlinear Darcy-Brinkman system in the vanishing Darcy number limit. In particular, we show the existence of a function of corner layer type (so called initial-boundary layer) in the solution of the nonlinear Darcy-Brinkman system. An approximate solution is constructed by the method of asymptotic expansion. We establish the optimal convergence rates in various Sobolev norms via energy method.

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MS32

Gevrey Regularity of the Critical and Supercritical

Quasi-Geostrophic Equations

The dissipative quasi-geostrophic (QG) equation is an important model in geophysical fluid dynamics, but also mathematically important since it can be considered as a 2D model of the 3D incompressible Navier-Stokes equations. Consequently, it has received much attention in recent years. Studies of this equation are usually separated into three cases: supercritical, critical, and subcritical, where in each case the order of dissipation increases. By now, the subcritical case is well understood; global existence of weak solutions was established in [Resnick, '95], while global existence of a unique regular solution with initial data in L^p-spaces, for instance, was established in [Wu, '01]. Recently, global well-posedness for arbitrary smooth initial data was established by several authors independently: [Caffarelli-Vasseur, '06], [Kiselev-Nazarov-Volberg, '07], and [Constantin-Vicol, '11]. However, there is still much that is not known in the supercritical and even, critical case. Our paper explores higher-order regularity of the supercritical and critical QG equation. In particular, we establish Gevrey regularity of solutions in L^p-based Besov spaces. The techniques we use are based on the ideas of [Miura, '06] and an extension of those in [Biswas, preprint], where the main idea is to establish control on the nonlinear term via a suitable commutator estimate. Since we seek L^p bounds, we adapt the approach of [Lemarie-Rieusset, '99] and view the commutator as a bilinear multiplier operator. However, to establish these bounds, we must also adopt the techniques of Michael Lacey and Christoph Thiele used to the bound the Bilinear Hilbert Transform. As an application, we also deduce higher-order decay estimates on the solution.

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MS33

High Order Finite Elements for Wave Propagation: Like It Or Lump It?

High order finite element methods have long been used for computational wave propagation for both first order and second order equations alike. A key issue with computational wave propagation is the phase accuracy of the methods: getting the waves to propagate with the right speed is often at least as, if not more, important than the convergence rate. The main variants are the finite element method (FEM) and spectral element method (SEM) with each technique having its band of advocates. SEM can be viewed as a higher order mass-lumped FEM. Despite the predominance of these methods, there is comparatively little by way of hard analysis on what each variant offers in terms of phase accuracy, and there is considerable misinformation and confusion in the literature on this topic. In this presentation, we shall attempt to shed some light on the matter, and also briefly mention new methods that improve on both FEM and SEM

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MS33

An Element Conservative Dpg Method for Convection-Dominated Problems

Abstract not available at time of publication.

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MS33

Dissipative Methods for Wave Equations in Second Order Form

We consider the construction and analysis of high-order dissipative elements for solving time-domain wave equations in second order form. These include natural generalizations of dissipative methods for first order hyperbolic systems including upwind discontinuous Galerkin methods as well as Hermite methods.The essential ingredient in the generalization is to consider the standard energy form for second order wave equations as well as its space derivatives. We demonstrate that the proposed methods can be stably hybridized.

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MS33

Mixed Finite Elements for Wave Equations

I will survey several of the issues facing numerical approximation of wave equations by finite element methods – before considering stability and accuracy, we must decide whether to use first- or second-order forms of the equations. We must deal with numerical dispersion, inverting mass matrices at each time step and energy conservation/dissipation properties of our numerical solutions. After setting the stage for many of the presentations of the minisymposium, I will present some recent results along these lines for mixed finite element discretization of the acoustic wave and linear shallow water equations. These include nearly-conservative symplectic time-stepping, conversion between first- and second-order, and the effect of a drag term on energy balances.

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MS34

Analysis of the Two-Phase Flow in Rotating Hele-Shaw Cells with Coriolis Effects

The free boundary problem of a two phase flow in a rotating Hele-Shaw cell with Coriolis effects is studied. Existence and uniqueness of solutions near spheres is established, and

the asymptotic stability and instability of the trivial solution is characterized in dependence on the fluid densities.

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MS34

Crystal Facets: From Microscale Motion to Singular-Diffusion Pdes

Continuum theories of epitaxial growth usually break down in the vicinity of macroscopically flat surface regions (facets). In surface diffusion, such facets give rise to free-boundary problems with non-trivial microstructure for fourth-order singular-diffusion PDEs. In this talk, I will present recent progress in coupling facet motion with discrete (microscale) schemes for surface atomic defects (steps) under surface diffusion.

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MS34

Examples of Singular Diffusion Equations in One and Two Dimension: Facets and More

We focus on a simple singular diffusion equation (i.e. a total variation flow in 1-d) and its counterpart regularized by additive linear diffusion. We study these two equations in one and two dimensions. After quickly establishing existence, uniqueness and regularity we concentrate on creation, evolution and interaction of facets. We also exhibit a number of explicit solutions.

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MS34

On Singular Perturbation Limit of the Allen-Cahn Equation

We present some results on the characterization of energy concentration measure for the Allen-Cahn equation as the thickness of interface approaches to zero. The limiting interface moves with velocity equals to its mean curvature plus given ambient vector field with low regularity. This is a joint work with Keisuke Takasao.

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MS35

Unconditional Uniqueness for the Cubic Gross-Pitaevskii Hierarchy via Quantum de Finetti - Part II

The derivation of nonlinear dispersive PDE, such as the nonlinear Schrödinger (NLS) or nonlinear Hartree (NLH) equations, from many body quantum dynamics is central topic in mathematical physics, which has been approached by many authors in a variety of ways. In particular, one way to derive NLS is via the Gross-Pitaevskii (GP) hierarchy, which is an infinite system of coupled linear non-homogeneous PDE. The most involved part in such a derivation of NLS consists in establishing uniqueness of solutions to the GP. That was achieved in seminal papers of Erdös-Schlein-Yau. Recently, with Hainzl and Seiringer we obtained a new, simpler proof of the unconditional uniqueness of solutions to the cubic Gross-Pitaevskii hierarchy in $\mathbb{R}^3$. One of the main tools in our analysis is the quantum de Finetti theorem. In the first talk, Pavlovic will present a brief review of the derivation of NLS via the GP, describing the context in which the new uniqueness result appears. In the second talk, Chen will illustrate how quantum de Finetti's theorem can be used to obtain unconditional uniqueness of the GP.

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MS35

The 2d Schrödinger Equation on Irrational Tori

Abstract not available at time of publication.

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MS35

Unconditional Uniqueness for the Cubic Gross-Pitaevskii Hierarchy via Quantum de Finetti-Part I

The derivation of nonlinear dispersive PDE, such as the nonlinear Schrödinger (NLS) or nonlinear Hartree (NLH) equations, from many body quantum dynamics is central topic in mathematical physics, which has been approached by many authors in a variety of ways. In particular, one way to derive NLS is via the Gross-Pitaevskii (GP) hierarchy, which is an infinite system of coupled linear non-homogeneous PDE. The most involved part in such a derivation of NLS consists in establishing uniqueness of solutions to the GP. That was achieved in seminal papers of Erdös-Schlein-Yau. Recently, with Chen, Hainzl and Seiringer we obtained a new, simpler proof of the unconditional uniqueness of solutions to the cubic Gross-Pitaevskii hierarchy in $\mathbb{R}^3$. One of the main tools in our analysis is the quantum de Finetti theorem. In the first talk, Pavlovic will present a brief review of the derivation of NLS via GP describing the context in which the new uniqueness result appears. In the second talk, Chen will illustrate how quantum de Finetti's theorem can be used to obtain unconditional uniqueness of the GP.

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MS35

Blow Up Solutions in the Focusing NLS

Abstract not available at time of publication.

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MS36

Wide-Stencil and Filter Schemes for Monge Ampere Equations

Abstract not available at time of publication.

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MS36

Optimal Transport with Proximal Splitting

We here present the use of first order convex optimization schemes to solve the discretized dynamic optimal transport problem, initially proposed by Benamou and Brenier. We develop a staggered grid discretization that is well adapted to the computation of the L^2 optimal transport geodesic between distributions defined on a uniform spatial grid. We show how proximal splitting schemes can be used to solve the resulting large scale convex optimization problem. A specific instantiation of this method on a centered grid corresponds to the initial algorithm developed by Benamou and Brenier. We also show how more general cost functions can be taken into account and how to extend the method to perform optimal transport on a Riemannian manifold.

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MS36

Optimal Transportation with Infinitely Many Marginal

Abstract not available at time of publication.

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MS36

Optimal Transport for Illumination Optics

The design of freeform reflectors and lenses for illumination systems has become very relevant with the rise of LEDs. The problem is closely related to optimal transport. We developed a method to design convex or concave reflectors based on a novel numerical method for the Monge-Ampère equation and a numerical Legendre-Fenchel transform. I will give an example of a reflector that projects a famous Dutch painting on a wall from a uniform parallel light beam.

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MS37

Exact Controllability of a Membrane Immersed in a Potential Fluid

We consider the problem of controlling a membrane or plate that is either immersed in a (linearized) potential fluid,or forms a portion of the boundary of a potential fluid. The control acts along a portion of the boundary of the membrane. We show that for sufficiently small fluid density, and time large enough (related to the geometry of the membrane), exact controllability holds in the finite energy space.

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MS37

On Incompressible Two-Phase Fluid Flows with Phase Transitions

We consider a sharp interface model for two-phase flows with surface tension undergoing phase transitions. The model is based on conservation of mass, momentum and energy, and hence is physically exact. It further employs the standard constitutive law of Newton for the stress tensor, Fourier's law for heat conduction, and it is thermodynamically consistent. We establish well-posedness of the model and study the qualitative behavior of solutions. In particular, we characterize all equilibria and study their stability properties. The total entropy turns out to be an important quantity in the stability analysis.

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MS37

On the Two-phase Navier-Stokes Equations in Cylindrical Domains

We consider the dynamics of two incompressible fluids in

a cylindrical domain, separated by a sharp interface. The contact angle is assumed to be constant and equal to 90 degrees. We prove the well-posedness of the corresponding free boundary problem and we present results concerning the stability of equilibria (Rayleigh-Taylor instability). Finally we present a result on bifurcation at multiple eigenvalues.

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MS37

Min-Max Game Problem for Elastic and Visco-Elastic Fluid Structure Interactions

We present the features of a min-max game theory problem for a linear fluid-structure interaction model in both elastic and visco-elastic case, with (possibly) control and disturbance exercised at the interfce between the two media. The sought-after saddle solutions are expressed in a pointwise feedback form, which involves a Riccati operator; that is, an operator satisfying a suitable non-standard Riccati differential equation.

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MS38

On the Behavior of Bounded Vorticity, Bounded Velocity Solutions to the 2D Euler Equations

I will present recent work characterizing all possible weak solutions to the 2D Euler equations in the full plane or the exterior of a single obstacle having bounded velocity and bounded vorticity. The class of all such solutions generalizes the solutions obtained originally by Phillipe Serfati in 1995 for the full plane, which have sublinear growth of the pressure at infinity. For more general solutions a condition at infinity, in terms of the velocity or the pressure, holds weakly, and the circulation about the obstacle can vary for an exterior domain. These results build on those of joint work with Ambrose, Lopes Filho, and Nussenzveig Lopes.

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MS38

On Vorticity Formulation for the Navier-Stokes Equations in the Half Plane and Its Applications to the Inviscid Limit Problem

We consider the Navier-Stokes equations for viscous incompressible flows in the half plane under the no-slip boundary condition. By using a vorticity formulation we prove time-local convergence of the Navier-Stokes flows to the Euler flows outside a boundary layer and to the Prandtl flows in the boundary layer at the inviscid limit when the initial vorticity is located away from the boundary.

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MS38

Planar Limits of 3D Helical Flows

We study the limits of three-dimensional helical viscous and inviscid incompressible flows in an infinite circular pipe, with respectively no-slip and no-penetration boundary conditions, as the step approaches infinity. We show that, as the step becomes large, the three-dimensional helical flow approaches a planar flow, which is governed by the so-called two-and-half Navier-Stokes and Euler equations, respectively. The step or pitch is the magnitude of the translation after rotating one full turn around the symmetry axis.

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MS38

Remarks on the Question of Dissipation Anomaly for the Navier-Stokes and Euler Equations

Dissipation Anomaly is one of the well-defined mathematical problems in turbulence theory. It states that the mean rate of dissipation of energy of viscous turbulent flows remains bounded away from zero, as the viscosity tends to zero. We will provide simple examples demonstrating this phenomenon, and explaining the idea behind the available rigorous results. These examples illustrate that the current mathematical formulation might not be adequate; and another formulation is proposed ruling out these examples.

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MS39

Title Not Available at Time of Publication

Abstract not available at time of publication.

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MS39

Deriving the Kubelka-Munk Equations from Radiative Transport

Kubelka-Munk theory provides a simple model to describe for light propagation in turbid media. We derive this theory systematically from the theory of radiative transport theory by analyzing the system of equations resulting from applying the double spherical harmonics method. From this systematic derivation, we establish theoretical basis of the Kubelka-Munk equations which has been an outstanding issue. Moreover, we extend this theory to study several problems of practical interest.

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MS39

Case's Method in Three Dimensions

Case's method obtains solutions to the radiative transport equation as a linear combination of elementary solutions or singular eigenfunctions. In this talk, we will extend the method to three dimensions with arbitrary anisotropic scattering. We evaluate singular eigenfunctions in reference frames whose z-axes are taken in the direction of each wave vector. By doing so, the three-dimensional equation reduces to the one-dimensional equation.

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MS39

Filtered Spherical Harmonics Expansions of the Radiative Transfer Equation

Recent work has shown that various filtering schemes can greatly improve the robustness of moment-based methods for solving the radiative transfer equation. In this talk I will outline several approaches used to filter spherical harmonics moments and apply these filters to the transport solutions for problems of linear particle transport as well has nonlinear x-ray transport. I will also detail how filters can be employed to improve discrete ordinates methods and talk about nonlinear extensions.

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MS40

On the Benjamin-Feir Instability

I will speak on the Benjamin-Feir (or modulational) instability of Stokes periodic waves on deep water. I will begin by describing a variational framework that I recently developed with J. Bronski and determine instability to long wavelengths perturbations for a general class of Hamiltonian systems, allowing for nonlocal dispersion. I will explain an asymptotic approach that M. Johnson and I adapted for Whitham's equation of surface water waves, qualitatively reproducing the Benjamin-Feir instability of Stokes waves. I will discuss on how to extend the results to the exact, water wave problem.

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MS40

Pressure Beneath a Traveling Wave with Constant Vorticity

In this talk I will give a brief overview of two-dimensional traveling gravity waves with constant vorticity, with and without stagnation points. Following this, I will present a direct relationship between the surface profile of the traveling wave and the pressure at the bottom of the fluid. This relationship is obtained as a direct consequence of the full equations describing the traveling wave without approximation. Using this relationship, we reconstruct both the pressure and streamlines throughout the fluid domain. In particular, we can recover local minima of the pressure (below the atmospheric value) beneath the crest in the presence of a stagnation point.

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MS40

Mathematical Theory of Wind-generated Water Waves

It is easy to see that wind blowing over a body of water can create waves. But this simple observation leads to a more fundamental question: Under what conditions on the velocity profile of the wind will persistent surface water waves be generated? This has been problem has been studied intensively in the applied fluid dynamics community since the first efforts of Kelvin in 1871. In this talk, we will present a mathematical treatment of the predominant model for wind-wave generation, the so-called quasi-laminar model of J. Miles. Essentially, this entails determining the (linear) stability properties of the family of laminar flow solutions to the two-phase interface Euler equation. We give a rigorous derivation of the linearized evolution equations about an arbitrary steady solution, and, using this, we give a complete proof of the celebrated instability criterion of Miles. In particular, our analysis incorporates both the effects of surface tension and a vortex sheet on the air–sea interface. We are thus able to give a unified equation connecting the Kelvin–Helmholtz and quasi-laminar models of wave generation.

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MS40

Large-Amplitude Solitary Waves Generated by Surface Pressure

We study solitary traveling waves in a two-dimensional inviscid incompressible fluid bounded below by a horizontal bed and above by a free surface on which a non-constant pressure is applied. By varying the surface pressure, we construct large-amplitude waves of elevation and depression. We assume that the wave and surface pressure are symmetric, and that the Froude number of the underlying flow is sufficiently large (supercritical).

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MS41

On the Parametrized Maximum Principle Flux Limiters for Hyperbolic Conservation Laws: Accuracy and Application

Maximum principle preserving is an important property of the entropy solution, the physically relevant solution, to the scalar hyperbolic conservation laws. One would like to imitate the property on the numerical level. On the other hand, preserving the maximum principle also provides a stability to the numerical schemes for solving the conservation law problem. In this talk, we will discuss how this problem is addressed by introducing a series of maximum principle constraint. By decoupling those constraints, a parametrized flux limiting technique is developed to make sure the numerical solution preserves maximum principle in the conservative and consistent manner while the scheme is still high order. Generalization of the technique to convection-diffusion problem will also be discussed.

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MS41

Stability Analysis and Error Estimates of an Exactly Divergence-Free Method for the Magnetic Induction Equations

In this talk, we consider an exactly divergence-free scheme to solve magnetic induction equations. This problem is extracted from the numerical simulations of ideal Magnetohydrodynamics (MHD) equations, which contain nonlinear hyperbolic equations as well as a divergence-free condition for the magnetic field. Numerical methods without satisfying such condition may lead to numerical instability. One class of methods called constrained transport schemes is widely used as a divergence-free treatment. However, why these schemes work is still not fully understood. In this work, we take the exactly divergence-free schemes proposed by Li and Xu as a candidate of the constrained transport schemes, and analyze the stability and errors when solving magnetic induction equations. This is the most significant part to understand the divergence-free treatment in MHD simulations. Our result can not only explain the stability mechanism of this particular scheme and the role of the exactly divergence-free condition in that, but also provide the insight to understand other constrained transport schemes.

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MS41

High Order Fast Sweeping and Homotopy Methods with Linear Computational Complexity for Solving Steady State Problems of Hyperbolic PDEs

In this talk, I present our recent studies on developing efficient high order numerical methods for solving steady state problems of two classes of hyperbolic PDEs: Eikonal equations and hyperbolic conservation laws. The methods we propose have linear computational complexity, namely, the computational cost is $O(N)$ where N is the number of grid points of the computational mesh. For Eikonal equations, we design a third order fast sweeping method with linear computational complexity. This iterative method utilizes the Gauss-Seidel iterations and alternating sweeping strategy to cover a family of characteristics of the Eikonal equations in a certain direction simultaneously in each sweeping order. The method is based on a third order discontinuous Galerkin (DG) finite element solver. Novel causality indicators are designed to guide the information flow directions of the nonlinear Eikonal equations. Numerical experiments show that the method has third order accuracy and a linear computational complexity. For hyperbolic conservation laws, a homotopy continuation method is applied to solve polynomial systems resulting from a third order weighted essentially non-oscillatory (WENO) discretization of the system. Via numerical experiments for both scalar and system problems in one and two dimensions, we show that this new approach has linear computational complexity and is free of the CFL condition constraint.

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MS41

Energy-conserving Discontinuous Galerkin Methods for the Vlasov-Ampère System

We propose energy-conserving numerical schemes for the Vlasov-Ampère (VA) systems. The VA system is a model used to describe the evolution of probability density function of charged particles under self consistent electric field in plasmas. It conserves many physical quantities, including the total energy which is comprised of the kinetic and electric energy. Unlike the total particle number conservation, the total energy conservation is challenging to achieve. For simulations in longer time ranges, negligence of this fact could cause unphysical results, such as plasma self heating or cooling. In our work, we develop the first Eulerian solvers that can preserve fully discrete total energy conservation. The main components of our solvers include explicit or implicit energy-conserving temporal discretizations, an energy-conserving operator splitting for the VA equation and discontinuous Galerkin finite element methods for the spatial discretizations. We validate our schemes by rigorous derivations and benchmark numerical examples such as Landau damping, two-stream instability and bump-on-tail instability.

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MS42

The Fractional Laplacian Operator as a Special Case of the Nonlocal Diffusion Operator

We analyze a nonlocal diffusion operator having as a special case the fractional Laplacian operator. We demonstrate that the solution of the nonlocal equation converges to the one of the fractional Laplacian as the nonlocal interactions become infinite. Through several numerical examples we illustrate the theoretical results and we show that by solving the nonlocal problem it is possible to obtain accurate approximations of the solutions of fractional differential equations circumventing the problem of treating infinite-volume constraints.

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MS42

Homogenization of the Nonlocal Navier System of Equations

Abstract not available at time of publication.

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MS42

Finite Element Calculations in One-Dimensional Peridynamics and Multiscale Mono-models

The peridynamics theory of solid mechanics is a generalization of classical continuum mechanics suitable for the simulation of material failure and damage. As a continuum model, peridynamics can be discretized through many different schemes. However, most of its current implementations use the so-called meshfree discretization, which reduces the governing equation to a discrete equation representing the dynamics of a system of virtual particles interacting in space; this discretization method is relatively inexpensive and suitable for simple implementations of bond-breaking criteria yet introduces important limitations on the choice of horizon, affecting the potential use of the theory in multiscale modeling. It is thus of interest to explore other possible discretization schemes. This presentation will be focused on the finite element method for peridynamics, applied to one-dimensional models. We will present element by element calculations and compare nonlocal results with their local counterparts based upon the finite element method for classical partial differential equations. We present analytical calculations for a certain choice of peridynamic kernel and demonstrate that the nonlocality of the peridynamic model depends upon the ratio of the horizon and the finite element mesh size. This result suggests a multiscale approach based upon different discretizations of a single model, which we referred to as a multiscale mono-model. Analytical results are supported by numerical experiments.

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MS43

Homogenization of High-Contrast Brinkman Flows

Porous media flow can have many scales and is often a multi physical processes. A useful tool in the analysis of such problems in that of homogenization as an averaged description is derived circumventing the need for complicated simulation of the fine scale features. In this talk, we recall recent developments of homogenization techniques in the application of flows high contrast media. We have particular emphasis on the Brinkmann equation and related numerical methods.

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MS43
Error Estimates for Mesoscale Continuum Models of Particle Systems

Abstract not available at time of publcation.

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MS43
Modeling Effective Acoustic Behavior of Porous Media with Microstructure

In this talk we present some recent results in mathematical modeling of porous media with multi-scale structure. In particular, we focus on effective acoustic properties of cancellous bone. Using two-scale convergence and other homogenization tools we derive effective material properties of the fluid-filled porous matrix. The effective equations are Biot-like, however they account for possible effects of micro-structural anisotropy.

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MS43
Effect of Slip Boundary Conditions on the Effective Behavior of Suspensions and Membranes

The first to depart from no-slip conditions for viscous fluids on a solid surface was Navier (1827) who imposed a slip condition that gives a linear dependence of the tangential velocity on the tangential stress. Threshold slip was introduced for viscous flow problems by Fujita (1994) who studied the existence and uniqueness for the Stokes problem with boundary conditions of the type $-(\sigma \mathbf{N})_\tau \in g\,\partial|\mathbf{u}_\tau|$, where $g \geq 0$. A similar threshold-type condition was introduced by Fujita to model leaky boundaries: the normal velocity is zero unless the jump in the normal stress across the membrane reaches an yield limit. We study the macroscopic effect of threshold slip for a suspension of rigid particles in a viscous fluid, and that of threshold leak for a permeable membrane. For suspensions, the Navier-Fujita type slip introduces at the macroscale a new fluid viscosity. For membranes, the effective boundary conditions are of subgradient type with an effective yield limit, in the case of a densely distributed solid part, or of Navier type, in the case of dilute solid part; in the intermediate case the tangential slip cancels, whereas the normal velocity and stress are continuous. Unlike in the case of perforated walls, no stress concentrations are present.

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MS44
On Incompressible Flows with Singular Velocities

The purpose of the talk is to establish several existence, uniqueness and ill-posedness results for two families of active scalar equations with velocity fields determined by the scalars through very singular integrals. The first family is a generalized surface quasi-geostrophic equation with the velocity field u related to the scalar θ by $u = \nabla^\perp \Lambda^{\alpha-1}\theta$, where $0 < \alpha \leq 1$ and $\Lambda = (-\Delta)^{1/2}$ is the Zygmund operator. The borderline case $\alpha = 0$ corresponds to the surface quasi-geostrophic equation and the situation is more singular for $\alpha > 0$. We obtain the local existence and uniqueness of classical solutions, the global existence of weak solutions and the local existence of patch type solutions. The second family is a singularly modified version of the 2D incompressible porous media equation with the velocity field v given by the scalar ρ as follows: $v = -\nabla\Lambda^{-2+\alpha}\partial_{x_2}\rho - (0, \Lambda^\alpha \rho)$, for $0 < \alpha \leq 1$. Here, the case $\alpha = 0$ yields Darcy's law. In contrast, for the last singular active scalar equation local well-posedness does not hold for smooth solutions, but it does hold for certain weak solutions.

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MS44
Big Box Limit for NLS

I will describe the derivation of a new equation from NLS on the torus with size L, in the weakly nonlinear regime, as L goes to infinity. I will then discuss various properties of this equation.

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MS44
Persistency of the Spatial Analyticity for Nonlinear Wave Equations and the Cubic Szego Equation

Gevrey classes were introduced by Maurice Gevrey in 1918 to generalize real analytic functions. Functions of Gevrey classes can be characterized by an exponential decay of their Fourier coefficients. This characterization has been proved useful for studying analytic solutions of various nonlinear PDEs, since the work by Foias and Temam (1989) on the Navier-Stokes equations. We use this technique to investigate the persistency of spatial analyticity for nonlinear wave equations (joint work with Edriss S. Titi), and the cubic Szego equation (joint work with Patrick Gerard and Edriss S. Titi). An advantage of this method is that it provides a lower bound for the radius of the spatial analyticity

of the solutions.

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MS44

Sensitivity Analysis with Respect to Principal Parameters of Long Time Dynamics in Hyperbolic Systems with Critical Exponents

We consider a third order in time equation which arises as a model of wave propagation in viscous thermally relaxing fluids. The nonlinear PDE model under consideration displays two important characteristics: (i) it is quasilinear and (i) it is degenerate in the principal part. The main goal of this talk is to present results on existence-nonexistence and decay rates for the solutions as a function of physical parameters in the equation. This is joint work with Barbara Kaltenbacher, University of Graz.

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MS45

Finite Element Exterior Calculus Methods for Geophysical Fluid Dynamics

We show how mixed finite element methods that fall into the finite element exterior calculus framework can be applied to the design of numerical weather prediction models. This investigation is being driven by the need to extend the properties of the C-grid finite difference staggering to arbitrary triangular/quadrilateral meshings of the sphere which are required for scalable massively parallel weather forecasting. We shall discuss the following: (a) Poisson structure, Casimirs, (b) geometric forms of stabilisation of the discretisation, (c) conservation laws, (d) treatment on curved elements, (e) extension to fully three dimensional models.

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MS45

Numerical Approximation of Boussinesq-Green-Naghdi Models for Near-Shore Wave Physics

Boussinesq-Green-Naghdi equations model the physics of waves in the near shore. They are approximations to the full Navier-Stokes equations where one assumes a vertical profile for the wave velocity. The resulting model is a highly nonlinear system of PDES with higher order derivatives, albeit in one less space dimension than the full model. The model is well-suited for discontinuous Galerkin approximations. We describe a general approach and discuss the accuracy and stability of the numerical approximation, as well as validation of the model against experimental data.

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MS45

Discontinuous Petrov Galerkin Methods for Wave Propagation

Discontinuous Petrov Galerkin (DPG) methods use standard trial spaces and nonstandard test spaces. The test spaces are automatically computed to obtain good stability constants. The resulting method can also be interpreted as a least-squares finite element method that minimize a residual in a nonstandard norm. In this talk, we report our results obtained by applying the DPG methodology to time-harmonic acoustic wave propagation. The main advantage of the method is that it yields Hermitian positive definite systems which are easier to solve. Other least-squares methods also have the same advantage, but we show how DPG methods improve on standard least-squares methods.

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MS45

DGSEM-ALE Approximation of Reflection and Transmission at Moving Interfaces

We derive a spectrally accurate moving mesh method for mixed material interface problems for Maxwell's and the classical wave equation. We use a discontinuous Galerkin spectral element approximation with an arbitrary Lagrangian-Eulerian mapping and derive the exact upwind numerical fluxes that model the physics of wave reflection and transmission at jumps in material properties. Spectral accuracy is obtained by placing moving material interfaces at element boundaries and solving the appropriate Riemann problem. We present examples showing the performance of the method for plane wave reflection and transmission at dielectric and acoustic interfaces.

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MS46

Stability Analysis of Flock Rings for 2nd Order Models in Swarming

In this work we consider second order models in swarming in which individuals interact pairwise with a power-law repulsive-attractive potentials. We study the stability for flock ring solutions and we show how the stability of these solutions is related to the stability of a first order model. In unstable situations it is also possible to observe formation of clusters and fat rings.

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MS46

Two Short Stories on Existence and Stability of N-Vortex Equilibria in Fluids

Abstract: Vortex relative equilibria are configurations of vortices that maintain their basic shapes for all time, while rotating or translating rigidly in space. It is common to observe these patterns in nature and experiments, where the underlying dynamics are governed, for example, by the two-dimensional Euler or Navier-Stokes equations. One can often take advantage of the structure of vortices to derive equations of motion that are much simpler than the original PDE. In this work, we look at two point vortex models to study the existence and stability of a number of relative equilibria. We complement this analysis with comparisons of our results to crystals observed in various experiments and numerical simulations.

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MS46

Bifurcation Dynamics in a Nonlocal Hyperbolic Model for Self-organised Biological Aggregations

The investigation of complex spatial and spatio-temporal patterns exhibited by self-organised biological aggregations has become a very active research area. Here, we focus on a class of nonlocal hyperbolic models for self-organised aggregations, and investigate the bifurcation dynamics of a variety of spatial and spatio-temporal patterns observed numerically near codimension-1 and codimension-2 bifurcation points.

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MS46

Vortex Crystals, Animal Skin Patterns and Ice Fishing

I will discuss three very different topics which turn out to have a related mathematical formulation. The first topic is classical vortex dynamics in the plane. We look for relative equilibria (lattice crystals) in the limit of large number of vortices. Many results for the steady state and its local stability can be obtained taking the mean-field limit. Next, we consider hot-spot solutions to certain reaction-diffusion PDE system. Similar PDE's are often used to model spots on the animal skins. We derive a reduced system of ODE's which describe the motion and locations of these spots. In certain regimes, we show that these ODE's are related to the relative equlibria of the vortex model. Finally, we describe the problem of mean first passage time. Suppose you live in Canada and you want to catch a fish in a lake covered by ice. Where do you drill a hole to maximize your chances? This question can be reformulated in terms of a random walk of brownian particle; the answer is given in terms of a certain optimization problem. Its solution is again related to vortex crystals. Joint work with: Yuxin Chen, Daniel Zhirov and Michael Ward

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MS47

Analysis of Point Defects in a Ferroelectric Liquid Crystal Using a Generalized Ginzburg-Landau Model

Defects in Smectic C* liquid crystal film cause distinctive spiral patterns in the texture of the film. This particular ferroelectric thin film is modeled by a generalized Ginzburg-Landau energy functional,

$$\frac{1}{2}\int_{\Omega} k_1(\text{div } u)^2 + k_2(\text{curl } u)^2 + \frac{1}{2\epsilon^2}(1-|u|^2)^2\,dx.$$

Given fixed boudary data of degree $d > 0$, we study the limiting configuration of a sequence of minimizers $\{u_\epsilon\}$ as $\epsilon \to 0$. We show the limit function contains d degree one singularities and near each, the function asymptotically has either a bend or splay pattern, depending on the relative values of k_1 and k_2. We also show that this functional has a renormalized energy that is minimized by the singularities of the limit function.

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MS47

Electric-Field-Induced Instabilities in Liquid-Crystal Films

Simple models of liquid crystals characterize orientational properties in terms of a *director field*, which can be influenced by an applied electric field. The local electric field is influenced by the director field; so equilibria must be computed in a coupled way. Equilibria are stationary points of a *free energy functional*, which can fail to be coercive because of the nature of the director/electric-field coupling. We discuss characterizations of local stability and anomalous behavior in such systems.

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MS47

Regularity Properties for Nematic Liquid Crystals

We investigate regularity properties for and bounds on local minimizers to an energy for nematic liquid crystals with a Maier-Saupe potential.

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MS48

Free-boundary Problems in Surface Evolution by Curvature Flows

We will discuss the qualitative properties of solutions to fully non-linear parabolic equations that arise from the evolution of hyper-surfaces by functions of their principal curvatures. Such examples include evolutions by powers of the Gaussian curvature or evolution by the harmonic mean of the principal curvatures. Since such equations become degenerate or singular the classical regularity results fail. We will discuss the optimal regularity of solutions and related free-boundary problems.

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MS48

A Classical Perron Method for Existence of Smooth Solutions to Boundary Value and Obstacle Problems for Degenerate-elliptic Operators via Holomorphic Maps

We prove existence of solutions to boundary value problems and obstacle problems for degenerate-elliptic, linear, second-order partial differential operators with partial Dirichlet boundary conditions using a new version of the Perron method. The elliptic operators considered have a degeneracy along a portion of the domain boundary which is similar to the degeneracy of a model linear operator identified by Daskalopoulos and Hamilton (1998) in their study of the porous medium equation or the degeneracy of the Heston operator (Heston, 1993) in mathematical finance. Our Perron method relies on weak and strong maximum principles for degenerate-elliptic operators, concepts of continuous subsolutions and supersolutions for boundary value and obstacle problems for degenerate-elliptic operators, and maximum and comparison principle estimates previously developed by the author (Feehan, 2012).

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MS48

Optimal Regularity and the Free Boundary in the Parabolic Signorini Problem

We give a comprehensive treatment of the parabolic Signorini problem based on a generalization of Almgren's monotonicity of the frequency. This includes the proof of the optimal regularity of solutions, classification of free boundary points, the regularity of the regular set and the structure of the singular set.

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MS48

Regularity of Solutions and of the Free Boundary of the Obstacle Problem for the Fractional Laplacian with Drift

We study the elliptic obstacle problem defined by the fractional Laplacian with drift,

$$\min\{Lu(x), u(x) - \varphi(x)\} = 0, \quad \forall x \in R^n,$$

where the operator L is defined by

$$Lu(x) = (-\Delta)^s u(x) + b(x)\cdot\nabla u(x) + c(x)u(x), \quad \forall x \in R^n.$$

In joint work with Arshak Petrosyan, we develop a new monotonicity formula and we establish the optimal regularity of solution, $C^{1,s}(R^n)$, and Lipschitz regularity of the free boundary in neighborhoods of regular points, in the case $1/2 < s < 1$. In the case $0 < s < 1/2$, the symbol associated to the operator L, $a(x,\xi) = |\xi|^{2s} + ib(x)\cdot\xi + c(x)$, is no longer elliptic. In joint work with Charles Epstein, we prove that if $Lu \in H^k(R^n)$, for some real constant k, and u is a tempered distribution, then u belongs to $H^{k+2s}_{loc}(R^n)$ and $b(x)\cdot\nabla u(x)$ belongs to $H^k_{loc}(R^n)$.

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MS49

Fluid-Structure Interaction Problems in Ocular Blood Flow

Ocular hemodynamics plays a crucial role in the pathophysiology of several ocular diseases, including glaucoma, age-related macular degeneration and diabetic retinopathy. The mathematical modeling of ocular blood flow involves the motion of a fluid (blood) through deformable elastic structures. In this talk, we will present a model describing the blood flow through the lamina cribrosa, a collagen structure structure that is pierced by the central retinal vessels approximately in its center and maintains the pressure difference between the intraocular pressure inside the eye globe and the retrolaminar tissue pressure inside the optic nerve canal. The analytical properties of the model, based on the theory for poroelastic materials, will be discussed and its numerical solutions will be presented for various clinically-relevant scenarios.

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MS49

Intrinsic Decay Rates for the Energy of Second Order Nonlinear Evolutions with Viscoelasticity

Nonlinear second order evolutions subject to viscoelastic damping are considered. It is well known that the stability characteristics of finite energy solutions are dependent on the decay properties of the relaxation kernel. The aim of the talk is to present sharp decay rates of solutions corresponding to relaxation kernels without quantified asymptotic behavior. The obtained decay rates are described by solutions to appropriately constructed ordinary differential equations. Applications to nonlinear waves and von Karman systems of dynamic elasticity with memory will be given.

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MS49

Model Development and Uncertainty Quantification for Systems with Nonlinear and Hysteretic Actuators

Smart material actuators and sensors provide unique control capabilities for a range of applications involving fluid-structure and flow-structure interactions. These include PZT-based macrofiber composites which are being considered for flow control and shape memory alloys which are being tested for use as catheters employed for laser treatments of atrial fibrillation. In this presentation, we will discuss the development of a modeling framework for these systems that facilitates subsequent design, uncertainty quantification, and real-time control implementation for transducers operating in highly nonlinear and hysteretic regimes.

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MS49

New Advances and Open Problems in Nonlinear Flow-Plate Interactions

We address nonlinear PDE models arising in the study of flow-plate interactions and the associated phenomenon (e.g. flutter). We will review the recent well-posedness and long-time behavior results for a clamped, non-rotational plate immersed in a supersonic flow. Additionally, we address novel mathematical challenges associated to the well-posedness theory for other physical configurations of recent experimental and numerical interest: specifically, the Kutta Joukowsky flow condition and free plate boundary conditions.

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MS50

Regularity of Solutions to the Axisymmetric Euler Equations

We investigate properties of solutions to the axisymmetric Euler equations when initial vorticity belongs to a space of Besov type. In particular, we study regularity of solutions when a certain Besov norm of initial vorticity diverges in a controlled way.

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MS50

Hölder Continuous Euler Flows

Motivated by the theory of hydrodynamic turbulence, Lars Onsager conjectured in 1949 that solutions to the incompressible Euler equations with Hölder regularity below 1/3 may fail to conserve energy. I will discuss Onsager's conjecture and recent progress towards this conjecture, including the construction of solutions to Euler which are $(1/5-\epsilon)$-Hölder continuous and fail to conserve energy.

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MS50

Nonlinear Stability of Vortex Pairs

In this talk, we discuss nonlinear orbital stability for steadily translating vortex pairs, a family of nonlinear waves that are exact solutions of the incompressible, two-dimensional Euler equations. We use an adaptation of Kelvin's variational principle, maximizing kinetic energy penalised by a multiple of momentum among mirror-symmetric isovortical rearrangements. This formulation has the advantage that the functional to be maximized and the constraint set are both invariant under the flow of the time-dependent Euler equations, and this observation is used strongly in the analysis. Previous work on existence yields a wide class of examples to which our result applies.

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MS51

Algebraic Vortex Spirals

Vortex spirals are ubiquitous in fluid flow, for example as turbulent eddies or as trailing vortices at aircraft wings. However, there are few proofs of existence for any of the common fluid models. We consider solutions of the incompressible Euler equations that have vorticity stratifying into algebraic spirals. The solutions are selfsimilar: velocity $v(t,x) = t^{m-1}v^(t^{-m}x)$, for similarity exponent $\frac{1}{2} < m < \infty$. Selfsimilar flows are special solutions of the full initial-value problem, but obtained by solving more

tractable boundary value problems. The key to the existence proof is an coordinate change which is implicit, depending on the a priori unknown solution. We will also discuss the importance of the program for showing nonuniqueness in the initial-value problem for the 2d incompressible Euler solutions.

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MS51

Linear and Nonlinear Reflection Patterns in Gas Dynamics

The analysis of self-similar, non-potential flow for the equations of gas dynamics involves the interaction of the nonlinear family of acoustic waves with the linear, degenerate family or families of shear (and possibly entropy) waves. We examine a simple pattern, regular reflection of a shock at wedge near the reflection point. Behind a transonic shock, the self-similar equations change type, with the acoustic waves now corresponding to a second-order elliptic equation coupled with a hyperbolic component corresponding to the shear waves (in isentropic flow). The elliptic solution operator is compact, while the transport system gives rise to a contraction. We show how to couple these to produce a local solution.

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MS51

Hyperbolic Techniques for Multidimensional Interface Dynamics

We are interested in interfacial dynamics in continuum mechanics which are governed by hyperbolic evolution equations in the bulk and appropriate transfer conditions across the interface. Instances of bulk systems are provided by compressible Euler equations for liquid-vapour flow, nonlinear elasticity for solid-solid transitions, or Buckley-Leverett type formulations for in porous media flow. Transfer conditions have not only to gurantee conservation properties but account for e.g. curvature, phase transition or connect different types of bulk physics. To track the interfaces' local dynamics IVPs in normal directions are considered. This leads to generalized Riemann problems which are hardly to solve exactly. We will introduce approximations which rely on regularization or hyperbolic-elliptic relaxation. The convergence of the approximations and the (non)validity of entropy conditions are discussed.

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MS51

The Onset of Cavitation for the Equations of Polyconvex Elasticity

Cavitation refers to the opening of holes during the dynamic deformation of an elastic material and is a phenomenon that lies at the boundary of continuum modeling. We will describe a solution constructed by Pericak-Spector and Spector describing a cavity opening from a homogeneously deformed state. This poses challenges to the existence theory of multi-d conservation laws, as the constructed cavitating solution turns out to decrease the mechanical energy. We will analyze this example from the perspective of a theory that accounts for the singular layers of the cavitating solution. We call the resulting notion of solution as singular limiting induced from continuum solution. It turns out that this perspective can account for the cost of energy associated with producing the cavity, and that the resulting energy of the cavitating solution is larger than that of a homogeneously deformed state.

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MS52

Asymptotic Approximation of the Dirichlet to Neumann Map of High Contrast Conductive Media

I will present an asymptotic study of the Dirichlet to Neumann map of high contrast composite media with perfectly conducting inclusions that are close to touching. The result is an explicit characterization of the map in the asymptotic limit of the distance between the particles tending to zero.

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MS52

Anomalous Diffusion of a Tracer Particle in Fast Cellular Flow

It is well known that a diffusive tracer particle in the presence of an array of strong opposing vortices (aka cellular flow) behaves like an effective Brownian motion on long time scales. On intermediate time scales, however, a robust anomalous diffusive behaviour has been numerically observed. This talk is a first step towards understanding this anomalous behaviour. We will show that the variance of the particle behaves like $O(\sqrt{t})$ on "intermediate" time scales; in contrast, the long time behaviour of the variance is like $O(t)$.

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MS52

Asymptotic Expansion for Wave Propagation in a Media with a Small Hole

In this talk, I will discuss the asymptotic expansion of the acoustic field under the effect of a small hole in the quasi-static regime. As a consequence, one can prove that the gradient of the field is "bounded". This is joint work with Reitich and Lin.

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MS52

Title Not Available at Time of Publication

Abstract not available at time of publication.

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MS53

Tight-Binding Approximations and Edge States in Honeycomb Optical Lattices

Over the last several years, a great deal of interest has emerged over honeycomb optical lattices, which are modeled by a Gross-Pitaevskii (GP) equation with a periodic, two-dimensional potential. Using a tight-binding approximation in the semi-classical limit, a two-dimensional nonlinear discrete system has been derived as an approximation to the GP equation. We present results that establish the validity of this approximation on asymptotically long time scales. By introducing an edge into the discrete system, we then present results on the propagation of modes localized along the edge, or edge modes. Ignoring nonlinearity, one can find a plethora of linear edge modes, but a central question is what is the impact of nonlinearity on these problems. In the case of weak nonlinearity, we have developed a rigorously justified approximation describing the impact of nonlinearity on the linear modes. The most important result from this is that the nonlinearity does not cause delocalization away from the edge. In the case of strong nonlinearity, we present numerical results which show the nonlinearity does not cause delocalization, and thus edge modes should be a stable feature for optical lattices with edges.

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MS53

Elastic Cloaking for Civil Structures

The talk will present some mathematical framework for elastic cloaking and will be followed by some numerical illustration and an experiment on seismic metamaterial. Such concepts have been developed in conjunction with the earlier works by Milton, Briane Willis (cloaking preserving the symmetry of the elasticity tensor), Norris (acoustic cloaking with pentamode materials) and Brun, Guenneau, Movchan (cloaking with an elasticity tensor without the minor symmetries). The large-scale seismic test held on a soil metamaterial using vibrocompaction probes is the first application of cloaking to civil engineering. Joint work with S. Enoch, A. Diatta, S. Brûlé and E. Javelaud.

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MS53

Engineering Anisotropy to Amplify a Long Wavelength Field Without a Limit

We present a simple design of circular or spherical shells capable of amplifying a long wavelength or static field. This design makes use of only two isotropic materials and is optimal restricted to the prescribed geometric and materials constraint. Further, it is shown that the amplification factor of the structure can be made arbitrarily large as the ratio of the radius of the inner sphere to that of the outer sphere decreases to zero. It is anticipated that the presented design will be useful for high gain antenna for telecommunication, magnets generating strong, local uniform fields, and thermoelectric devices harvesting thermal energy.

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MS53

Pathological Scattering in the Resonant Slow-Light Regime

Layered media consisting of alternating magnetic and anisotropic components were shown by Figotin and Vitebskiy to admit an electromagnetic mode of zero energy flux at a frequency in the interior of a propagation band; operation near this frequency is called the "slow-light" regime. We consider scattering of waves by a planar defect embedded in a slow-light ambient medium. The scattering problem is pathological because three eigenmodes coalesce into the one zero-flux mode as branches of a Puiseux series in a perturbation parameter ?, and the completeness and independence of the rightward and leftward modes breaks down. It is even more pathological when the defective layer admits a guided resonant mode exactly at the slow-light parameters (?=0). The unusual scattering phenomena fit into a perturbative linear-algebraic setting; the players are a fixed indefinite flux form in C^4, an analytic flux-unitary transfer matrix T(?), and an analytic flux-selfadjoint matrix K(?), where K(0) has a non-trivial Jordan block of size 3. Joint Work with Aaron Welters, MIT.

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MS54

On Forced Turbulence in Physical Scales of 3D NSE

We apply the physical scales framework to prove that Kolmogorov Dissipation Law $\varepsilon \sim U^3/L$ implies energy cascade in the 3D periodic NSE, provided the force is large enough. We also obtain restrictive scaling properties of the solutions in this case, and compare our results to the ones obtained in the classical Fourier framework.

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MS54

The Well-posedness Linear Hyperbolic Partial Differential Equations in a Rectangle

In this article, we consider the linear hyperbolic Initial Boundary Value Problems (IBVP) in a rectangle in both the constant and variable coe cients cases. We use semigroup method instead of Fourier analysis to achieve the well-posedness of the linear hyperbolic system, and we find by diagonalization that there are only two simple modes, which we call hyperbolic and elliptic modes in the system. The hyperbolic system in consideration is either symmetric or Friedrichs-symmetrizable. We also give some applications of our results.

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MS54

An Appropriate Notion of Attractor for Semi-Dissipative Equations

The large-time behavior of a dissipative system can often be understood by studying its global attractor, which can contain deep information about its underlying structure. We will show that the notion of attractor can be extended to systems with only partial dissipation, and apply the concept to fluid dynamics. We will see that this generalized attractor not only has a rich structure, but also encodes a wealth of turbulent phenomena in a single object.

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MS54

Existence and Uniqueness of Solutions for the Inviscid Shallow Water Equations

Motivated by the equations of the large scale oceans and atmosphere (primitive equations), we discuss the issue of existence and uniqueness of solutions for the linearized shallow water equations in space dimension two in a rectangle. We also study the nonlinear shallow water equations in some subcritical and supercritical situations. The choice of the suitable boundary conditions and the fact that the domain (rectangle) is not smooth, are two essential issues in this study. In particular we show how suitable boundary conditions make the initial and boundary problem mildly dissipative and well-posed.

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MS55

Nonstandard Dispersive Estimates and Long Time Existence for the 2d Water Wave Problem

In this talk, I will presents recent results on the relationship between the decay of a solution to the linearized water wave problem and its initial data and implications for the long time existence of gravity waves. Certain new decay bounds for a class of 1D dispersive equations (including the linearized water wave) display a surprising growth factor, which we show is sharp. A further exploration leads to a result relating singularities of the initial data at the origin in Fourier frequency to the regularity of solutions to these dispersive equations.

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MS55

Finite Time Blow-Up Versus Global Existence of Solutions for a 1D Fluid Model

We discuss the finite time blow-up versus global well-posedness for a 1D fluid model. This model may be derived by reducing the Navier-Stokes equations, the primitive equations, Burgers equations and many other fluid models. This is a joint work with K. Nakanishi and E. S. Titi.

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MS55

Scattering for Small Solutions of NLS with Subcritical Nonlinearity

We prove global existence and scattering for small scale invariant data for a model close to the standard cubic NLS. The proof is based on the method of normal forms. This is joint work with Vladimir Georgiev, University of Pisa.

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MS55

Justifying the Modulation Approximation of the

Full Water Wave Problem

In this joint work with Sijue Wu (U. Mich.), we consider solutions to the inviscid infinite depth water wave problem neglecting surface tension which are to leading order wave packets with small amplitude and slow spatial decay that are balanced. It has been known formally since Zakharov in the 60s that such solutions have modulations that evolve according to a focusing cubic NLS equation on very slow time scales. Justifying this rigorously is a real problem, since standard existence results for the water wave problem do not yield solutions which exist for long enough to see the NLS dynamics. Nonetheless, given initial data close to a wave packet in a suitable L^2 Sobolev space, we show that there exists a unique solution to the water wave problem which is close to the formal approximation for appropriately long times. This is done by applying the energy method to formulations of the evolution equations for the water wave problem in 2D and 3D developed by Sijue Wu with quadratic nonlinearities that are either absent or in some sense mild.

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MS56

On a Chemotaxis Model with Saturated Chemotactic Flux

We propose a PDE chemotaxis model, which can be viewed as a regularization of the Patlak-Keller-Segel (PKS) system. Our modification is based on a fundamental physical property of the chemotactic flux function – its boundedness. This means that the cell velocity is proportional to the magnitude of the chemoattractant gradient only when the latter is small, while when the chemoattractant gradient tends to infinity the cell velocity saturates. Unlike the original PKS system, the solutions of the modified model do not blow up. After obtaining local and global existence results, we use the local and global bifurcation theories to show the existence of one-dimensional spiky steady states; we also study the stability of bifurcating steady states. Finally, we numerically verify these analytical results. Joint work with A. Kurganov, X. Wang and Y. Wu

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MS56

G-Convergence of Elliptic Operators with Nonstandard Growth

We consider a class of monotone elliptic operators with nonstandard growth condition. We present a preliminary result on G-compactness under certain additional technical assumptions.

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MS56

Parabolic Equations Degenerating on a Part of the Domain

In this work we study nonlinear parabolic equations of the p-Laplace type degenerating on a part of the domain. The degeneration is controlled by a small parameter. For the fixed value of this parameter, the results we discuss fall within the scope of E. DiBenedetto's results. We obtain estimates uniform with respect to "epsilon" , thus extending the results, obtained earlier by Yu.A. Alkhutov and V.A. Liskevich in the linear case.

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MS56

Some Recent Progress on the Study of Behavior of Solutions of Degenerate Viscous Hamilton-Jacobi Equations

I will give a summary on a new approach to study large time behavior of solutions of degenerate viscous Hamilton-Jacobi equations. Then I will describe its applications to the usual cases, the obstacle problems, and the fully nonlinear cases.

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MS57

Stationary States and Asymptotic Behaviour of Aggregation Models with Nonlinear Local Repulsion

We consider a continuum aggregation model with nonlinear local repulsion given by a degenerate power-law diffusion with general exponent. The steady states and their properties in one dimension are studied both analytically and numerically, suggesting that the quadratic diffusion is a critical case. The focus is on finite-size, monotone and compactly supported equilibria. We also investigate numerically the long time asymptotics of the model by simulations of the evolution equation. Issues such as metastability and local/ global stability are studied in connection to the gradient flow formulation of the model.

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MS57

Modeling Selective Local Interactions with Mem-

ory

In this talk we present our recent results on stochastic particle methods for describing the local interactions between cyanobacteria. In these models, particles selectively choose one of their neighbors as the preferred direction of motion. Memory is incorporated into the model by allowing persistence. One- and two-dimensional models are studied.

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MS57

Minimization of an Energy Defined via an Attractive-Repulsive Interaction Potential Related to Nonlocal Aggregation Models

In this talk I will consider the constrained minimization of an energy defined via an attractive-repulsive interaction potential. This energy is related to aggregation models given by the equation $\rho_t + \nabla \cdot (\rho(-\nabla K * \rho))$ where ρ is the density of the aggregation and K is the interaction potential. Looking at the energy $E(\rho) = \int\int K(x-y)\rho(x)\rho(y)dxdy$ for interaction potentials of the form $K(|x|) = |x|^q/q - |x|^p/p$ in the parameter regime $-N < p < q$, we will establish the existence of minimizers under certain assumptions depending on the regime of powers p and q. Moreover, we will consider the binary density version of this energy where $\rho \in \{0,1\}$ and comment on the global minimizers when $q = 2$ and $p = 2 - N$. This is a joint work with R. Choksi and R. Fetecau.

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MS57

Title Not Available at Time of Publication

Abstract not available at time of publication.

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MS58

Mathematical Models for a Soap Opera

In this talk, I will put forth a new energy for the description of large distortions of lipid bilayers, which constitute the base component of cell membranes. This energy accounts for the soap-like liquid crystalline nature of lipid bilayers and the coupling between the deformations of lipid molecules and layers. The analogies between soap-like liquid crystals, with an infinite number of layers, and lipid bilayers, with only two layers, will be further discussed.

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MS58

Higher-Order Gradient Theories for Nematic Liquid Crystals

We explore the connection between mathematical theories describing defects in nematic liquid crystals and crystalline solids. The parallels between these theories allow us to propose an alternative framework for modeling nematic defects.

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MS58

Stability of Radially Symmetric Solution in Landau-De Gennes Theory of Liquid Crystals

Abstract not available at time of publication.

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MS58

Chevron Structures in Liquid Crystal Films

Abstract not available at time of publication.

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MS59

An Interface Capturing Method for Simulating Dynamic Gel-Fluid Interaction

Many problems in biology involve gels which are mixtures composed of a polymer network permeated by a fluid solvent (water). In some applications, free boundaries separate regions of gel and regions of pure solvent, resulting in a degenerate system. To overcome this difficulty, we develop a simple interface-capturing method that consists of a regularization procedure to solve the two-fluid model equations describing gels composed of two viscous fluids, in the situation in which the volume fraction of one fluid vanishes in part of the domain.

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MS59

Toward a Theory of Mutual Attractions and Repulsions of Floating Objects

The horizontal force experienced by two infinite parallel plates of possibly differing solid materials, situated vertically and partially immersed in an infinite fluid bath under gravity, is characterized in the context of classical surface tension theory. Varying kinds of behavior are encountered, depending on contact angles and on plate separation. The particular case, in which the two contact angles on the plate sides directly facing each other are supplementary, leads to a striking limiting instability.

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MS59

Coupling Between Fluid Equations and Fabric Surface Model

Abstract not available at time of publication.

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MS59

Compressible Navier-Stokes System with Temperature Dependent Viscosity and Heat Conductivity

The full system of compressible Navier -Stokes equations is the model for the compressible fluids with heat transfer. Particularly, Chapman-Enskog theory suggests the viscosity and heat conductivity of a fluid are powers of the temperature. Feireisl's type weak solution is constructed for this model.

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MS60

Weak Solutions for an Incompressible, Generalized Newtonian Fluid Interacting with a Linearly Elastic Koiter Shell

In this talk I will present an existence result for the interaction of an incompressible, generalized Newtonian fluid with a linearly elastic Koiter shell whose motion is restricted to transverse displacements. The moving middle surface of the shell constitutes the mathematical boundary of the three-dimensional fluid domain. I show that weak solutions exist as long as one can exclude selfintersections of the shell.

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MS60

A Constructive Existence Proof for a Moving Boundary Fluid-Multi-Layered Structure Interaction Problem

We consider a nonlinear, unsteady, moving-boundary problem of parabolic-hyperbolic-hyperbolic type modeling the interaction between a Newtonian fluid and an elastic structure composed of two layers: a thin layer modeled by the 1D wave equation, and a thick layer modeled by the 2D equations of linear elasticity. The thin layer is in contact with the fluid, thereby serving as a fluid-structure interface with mass. We will present a constructive proof of an existence of a weak solution.

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MS60

The Motion of the Rigid Body with Collisions in a Bounded Domain. Global Solvability Result

We consider the problem of motion of a rigid body in an incompressible viscous fluid, filling a bounded domain. This problem was studied by many autors. They considered classical non-slip boundary conditions, which gave them very PARADOXICAL result of no collisions of the body with the boundary of the domain. In this work we study when Navier slip conditions are prescribed on the boundary of the body (instead of non-slip conditions).We prove for this model the GLOBAL existence of weak solution, which permits COLLISIONS with the boundary of the domain.It is joint work with N. Chemetov.

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MS60

Global Existence and Nonlinear Stability for Fluid-structure Problems

I will discuss both viscous an inviscid fluid-structure interaction problems which couple either the Navier-Stokes or Euler equations to fully nonlinear thin elastic shell structures.

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MS61

Global Existence of Solutions to Fluid Structure Model with Moving Interface and Boundary Dissipation

Fluid structure interaction model comprising of a N-S equation coupled to a 3-D system of dynamic elasticity is considered. The coupling occurs on an interface between the two media and the model accounts for a free boundary of the solid which is moving within the fluid. The moving interface is subjected to a frictional damping. It is proved that solutions corresponding to sufficiently small initial data are unique and they exist globally. This result is established with minimal regularity assumptions imposed on the data and without any interior dissipation imposed on the structure. The only source of added dissipation is the interface (boundary) damping. This is, to our best knowledge, the first *global existence* result for fluid structure interaction in the 3 dimensional space. This is **joint work** with Michaela Ignatova (Stanford University), Igor Kukavica (University of Southern California) and Amjad Tuffaha (The Petrolium Institute, Abu-Dhabi, UAE)

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MS61

Steady Compressible Navier-Stokes-Fourier System with Temperature Dependent Viscosities

We consider the system of partial differential equations describing the steady flow of a compressible heat conducting Newtonian fluid in a bounded three-dimensional domain. We assume the pressure law of the form $p(\varrho, \vartheta) \sim \varrho^\gamma + \varrho\vartheta$ with $\gamma > 1$ and the viscosities $\sim (1+\vartheta)^\alpha$, $\alpha \in [0, 1]$. We show the existence of a weak or variational entropy solution for the above model in dependence on the parameters γ, α and the form of the heat flux.

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MS61

Generalized Stokes System and Implicit Constitutive Relations

We are interested in flows of incompressible fluids in which the deviatoric part of the Cauchy stress and the symmetric part of the velocity gradient are related through an implicit equation. Although we restrict ourselves to responses characterized by a maximal monotone graph, the structure is rich enough to include power-law type fluids, stress power-law fluids, Bingham and Herschel-Bulkley fluids, etc. We study Stokes-like problems wherein the inertial effects are neglected.

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MS61

Non-Newtonian Fluids - Applications of Orlicz Spaces in Theory of PDE

We are interested in the existence of solutions to strongly nonlinear partial differential equations, which come from dynamics of non-Newtonian fluids of a nonstandard rheology and abstract theory of parabolic equations. The nonlinear highest order term is monotone and coercivity/growth conditions are given by a general convex function. We study both types of nonlinearity: sub- and superlinear. Such a formulation requires a general framework, therefore we work with non-reflexive and non-separable Orlicz and Musielak-Orlicz spaces.

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MS62

Coupled Systems of Nonlinear Dispersive Wave Equations

Systems of wave equations which are coupled through nonlinear and dispersive effects arise in a number of applications. Unlike single equations, systems throw up far more diverse dynamics. This lecture will discuss a few of these in the context of coupled Korteweg-de Vries systems.

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MS62

The Regularity Criteria for 3D Magneto-hydrodynamic System

This work studies the regularity problem for the 3D Magneto-Hydrodynamic (MHD) system. We apply an approach of splitting the dissipation wavenumber combined with an estimate of the energy flux to obtain a new regularity criterion. This splitting approach was originally introduced by Cheskidov and Shvydkoy. The regularity criterion presented here is weaker than the existing criteria for the 3D MHD system.

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MS62

The Atmospheric Equations of Water Vapor with Saturation

In this lecture we will recall the atmospheric equations of water vapor with saturation, appearing as a nonlinear multivalued system of partial differential equations. We will address the issues of the definition of the solutions, and the questions of existence, uniqueness and regularity of solutions.

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MS62

Averaging and Spectral Properties of the 2D Advection-diffusion Equation in the Semi-classical Limit for Vanishing Diffusivity

Abstract not available at time of publication.

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MS63

Relative Entropy in Hyperbolic Relaxation of Balance Laws

We present a general framework for the approximation of systems of hyperbolic balance laws. The novelty of the analysis lies on the construction of suitable relaxation systems and the derivation of a relative entropy identity. We provide a direct proof of convergence in the smooth regime for a wide class of physical systems. We present results for systems arising in materials science, where the presence of source terms presents a number of additional challenges and requires delicate treatment. Our analysis is in the spirit and continuity of the previous work of A. Tzavaras (Comm. Math. Sci. 2005) for systems of hyperbolic conservation laws.

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MS63

On Multiphase Flow Models: Global Existence of Weak Solutions

This work is part of a research program whose objective is the analysis of nonlinear systems via the construction of suitable approximations and the establishment of appropriate compactness of the approximate solutions. Well-posedness results are presented for a class of such nonlinear systems.

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MS63

Global Weak Solutions to the Inhomogeneous Navier-Stokes-Vlasov Equations

In this talk, we are going to talk about the global weak solutions to the coupled system by the incompressible inhomogeneous Navier-Stokes equations and Vlasov equation in the three dimensional space.

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MS63

Shock-free Transonic Solutions to the Steady Euler System

We focus on the Ringleb exact solutions and build a family of solutions nearby for the steady Euler system in two space dimensions. For large amplitude flows, we implant a shock where the Ringleb-like solution would form a cusp.

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MS64

Long Time Influence of Small Perturbations

I will consider deterministic and stochastic perturbations of dynamical systems and stochastic processes with multiple invariant measures. Under certain conditions, the perturbed system in this case has a fast and a slow components. The slow component, which actually determines the long time behavior is a motion in the cone of invariant measures. The limiting slow motion can be described using the large deviation theory or by a modified averaging principle. I will demonstrate this approach in the case of the Landau-Lifshitz equation and for diffusion and wave fronts in narrow random channels.

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MS64

Asymptotic Behaviors for the Random Schrdinger Equation with Long-Range Correlations

Wave propagation in random media with long-range correlations was recently stimulated by data collections showing that propagation media can exhibit long-range correlation effects. Under the forward scattering approximation, the wave equation can be reduced to a random Schrdinger equation. In this talk, we will study the Schrdinger equation with a slowly decorrelating random potential, and show that the energy density of the wave function exhibits some anomalous diffusion phenomena.

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MS64

Linear Relaxation to Planar Travelling Waves in

Inertial Confinement Fusion

The models of ICF usually couple hydrodynamical features in plasmas with reaction-diffusion equations for the temperature. One of the main challenges is the non-linear heat diffusion of the porous media type, i-e $\nabla \cdot (\lambda \nabla T)$ with $\lambda = \lambda(T) = T^{m-1}$ for some conductivity exponent $m > 1$. In this talk we will consider an approximate non-linear parabolic equation for which there exist planar wave solutions having a physical meaning. Stability of these waves with respect to wrinkled perturbations is crucial for the ICF process to be effective. We show here that a diffusion-induced mechanism forces relevant perturbations to become planar exponentially fast in the long time regime, and also derive an asymptotic dispersion relation relating this rate of relaxation to some small temperature ratio $\varepsilon = T_{min}/T_{max} \to 0$. In this limit the problem degenerates into a free boundary one, and the proof involves a rescaled singular principal eigenvalue problem.

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MS64

Classical Limit for a System of Random Non-Linear Schrödinger Equations

This work is concerned with the semi-classical analysis of mixed state solutions to a Schrödinger-Poisson equation perturbed by a random potential with weak amplitude and fast oscillations in time and space. We show that the Wigner transform of the density matrix converges weakly and in probability to solutions to a Vlasov-Poisson-Boltzmann equation with a linear collision kernel. A consequence of this result is that a smooth non-linearity such as the Poisson potential (repulsive or attractive) does not change the statistical stability property of the Wigner transform observed in linear problems. We obtain in addition that the local density and current are self-averaging, which is of importance for some imaging problems in random media. The proof brings together the martingale method for stochastic equations with compactness techniques for non-linear PDE in a semi-classical regime. It partly relies on the derivation of an energy estimate that is straightforward in a deterministic setting but requires the use of a martingale formulation and well-chosen perturbed test functions in the random context.

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MS65

High Frequency Homogenization: Connecting the Microstructure to the Macroscale

It is highly desirable to be able to create continuum equations that embed a known microstructure through effective or averaged quantities such as wavespeeds or shear moduli. The methodology for achieving this at low frequencies and for waves long relative to a microstructure is well-known and such static or quasi-static theories are well developed. However, at high frequencies the multiple scattering by the elements of the microstructure, which is now of a similar scale to the wavelength, requires a dynamic homogenization theory. Many interesting features of, say, periodic media: band gaps, localization etc occur at these higher frequencies. The materials exhibit effective anisotropy and this leads to topical effects such as cloaking/ invisibility, flat lensing, negative refraction and to inducing directional behaviour of the waves within a structure. A general theory will be described and applications to continuum, discrete and frame lattice structures will be outlined. The results and methodology are confirmed versus various illustrative exact/ numerical calculations showing that theory captures, for instance, all angle negative refraction, ultra refraction and localised defect modes.

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MS65

Quantum Graph Spectral Analysis of Graphyne Structures

We will discuss spectral features (band-gap structure, Dirac points, etc.) of various graphene and graphyne structures. This is a joint work with N. T. Do and O. Post.

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MS65

Geometric Optimization of Laplace-Beltrami Eigenvalues

Let (M, g) be a compact Riemannian surface and denote by $lambda_k(M, g)$ the k-th eigenvalue of the Laplace-Beltrami operator, Δ_g. In this talk, we consider the dependence of the mapping $(M, g) \to lambda_k(M, g)$. In particular, we propose a computational method for solving the eigenvalue optimization problem of maximizing $lambda_k(M, g)$ over a conformal class $[g]$ of fixed volume, $vol(M, g) = 1$. We also consider the more general problem of letting M vary over all orientable compact surfaces of fixed genus. This is joint work with Chiu-Yen Kao and Rongjie Lai.

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MS65

Exponential Asymptotics for Line Solitons in Two-Dimensional Periodic Potentials

As a first step toward a fully two-dimensional asymptotic theory for the bifurcation of solitons from infinitesimal continuous waves, an analytical theory is presented for line solitons, whose envelope varies only along one direction, in general two-dimensional periodic potentials. For this two-dimensional problem, it is no longer viable to rely on a certain recurrence relation for going beyond all orders of the usual multiscale perturbation expansion, a key step of the exponential asymptotics procedure previously used for solitons in one-dimensional problems. Instead, we propose a more direct treatment which not only overcomes the recurrence-relation limitation, but also simplifies the exponential asymptotics process. Using this modified technique, we show that line solitons with any rational line slopes bifurcate out from every Bloch-band edge; and for each rational slope, two line-soliton families exist. Furthermore, line solitons can bifurcate from interior points of Bloch bands as well, but such line solitons exist only for a couple of special line angles due to resonance with the Bloch bands. In addition, we show that a countable set of multiline-soliton bound states can be constructed analytically. The analytical predictions are compared with numerical results for both symmetric and asymmetric potentials, and good agreement is obtained. This is joint work with Sean Nixon and T.R. Akylas.

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MS66

On the Temperature Variance Cascade in Surface Quasi-geostrophic Turbulence

Using a multi-scale, dynamical averaging methodology, we rigorously establish the existence of a temperature variance cascade across a range of physical scales in surface quasi-geostrophic turbulence.

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MS66

On Dynamics of Fluid Flows in Porous Media

We study the degenerate parabolic equation with time-dependent flux boundary condition for generalized Forchheimer (non-Darcy) flows of slightly compressible fluids in porous media. The solution is estimated, particularly for large time, in L^∞-norm, $W^{1,r}$-norm for $r \geq 1$, and $W^{2,2-\delta}$-norm for $\delta > 0$. The L^∞-estimates of the solution's time derivative are also obtained. We establish the continuous dependence of the solution on initial and boundary data. The De Giorgi and Ladyzhenskaya-Uraltseva iteration techniques are combined with uniform Gronwall-type estimates, specific monotonicity properties and suitable parabolic Sobolev embeddings. This is joint work with Thinh Kieu and Tuoc Phan.

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MS66

On the Existence of Pullback Attractors for the 3D Navier-Stokes Equations

The existence of attractors for the 2D Navier-Stokes equations has been thoroughly researched. In the nonautonomous case, when the uniform attractor exists, its sections have attraction properties which are in a pullback sense, when the initial conditions go to $-\infty$. I will present an abstract framework for studying the existence of pullback attractors for the nonautonomous 3D Navier-Stokes equations, where uniqueness of solutions is yet unresolved.

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MS66

Rate of Vertical Heat Transport in Rayleigh-Benard Convection

We discuss the scaling of the rate of heat transport in the vertical direction, quantified as the Nusselt number, within the Rayleigh-Benard model for convection. How the Nusselt number scales in terms of the parameters of the system, Rayleigh number and Prandtl number, is an outstanding open problem in classical physics. Both the case of finite Prandtl number, and the case of infinite Prandtl number will be discussed. Classical no-slip boundary condition as well as geophysically relevant free-slip boundary conditions will be investigated. The singular limit of infinite Prandtl number limit will also be discussed both in terms of finite-time trajectory convergence and in terms of convergence of long time statistical properties.

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MS67

Two Dimensional Water Waves In Holomorphic Coordinates

This article is concerned with the in nite bottom water wave equation in two space dimensions. We consider this problem expressed in position-velocity potential holomorphic coordinates. Viewing this problem as a quasilinear dispersive equation, we establish two results: (i) local well-posedness in Sobolev spaces, and (ii) almost global solutions for small localized data. Neither of these results are new; they have been recently obtained by Alazard-Burq-Zuily, respectively by Wu using different coordinates and methods. Instead our goal is improve the understanding of this problem by providing a single setting for both results, as well as new, somewhat simpler proofs.

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MS67

On the Spectral Stability of Kinks in Some PT-symmetric Nonlinear Equations

We consider the introduction of PT-symmetric terms in the context of classical Klein-Gordon field theories and explore their implications on the spectral stability of coherent structures. These models take the form $u_{tt} - u_{xx} + \varepsilon\gamma(x)u_t + f(u) = 0$, where $\gamma(x)$ is an odd function. In particular, for the corresponding static kink solutions of the sine-Gordon equation and the Klein-Gordon equation with nonlinearity $f(u) = 2(u^3 - u)$ we prove spectral stability for all small enough ε.

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MS67

Global Exact Controllability of Semilinear Plate Equations

I will discuss some exact controllability results for semilinear hyperbolic PDE's. In early 1990's it was demonstrated by Lasiecka and Triggiani that the global exact interior and boundary controllability holds for many wave and plate models with nonlinear source terms, provided the source feedback maps are globally Lipschitz. In the special case of localized interior controls these theorems have been extended by Li and Zhang to sources that are at most "logarithmically superlinear" at infinity. I will present some nascent developments concerning global exact controllability for plate equations with more general polynomially bounded sources.

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MS68

Upscaling of Forchheimer Flows

In this work we propose upscaling method for nonlinear Forchheimer flow in highly heterogeneous porous media. The generalized Forchheimer law is considered for incompressible and slightly-compressible single-phase flows. We use recently developed analytical results by E.Aulisa, L.Bloshaskaya, L.Hoang, and A.Ibragimov [J. Math. Phys. 50, 103102 (2009)] and formulate the resulting system in terms of a degenerate nonlinear flow equation for the pressure with the nonlinearity depending on the pressure gradient. The coarse scale parameters for the steady state problem are determined so that the volumetric average of velocity of the flow in the domain on fine scale and on coarse scale are close. A flow-based coarsening approach is used, where the equivalent permeability tensor is first evaluated following streamline methods for linear cases, and modified in order to take into account the nonlinear effects. The developed upscaling algorithm for nonlinear steady state problems is effectively used for variety of heterogeneities in the domain of computation. Direct numerical computations for average velocity and productivity index justify the usage of the coarse scale parameters obtained for the special steady state case in the fully transient problem. For nonlinear case analytical upscaling formulas in stratified domain are obtained. Numerical results were compared to these analytical formulas and proved to be highly accurate. This is the joint work with E.Aulisa, A.Ibragimov and Y.Efendiev.

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MS68

Two-phase Generalized Forchheimer Flows

We study two-phase generalized Forchheimer flows of incompressible fluids in porous media. A family of nonconstant symmetric steady states are obtained. We prove that they are linearly asymptotically stable in case of bounded domains. For unbounded domains, we obtain the stability results and the behavior of the solutions of the linearized system at space-infinity. The lemmas of growth of Landis-type are established with explicit barrier functions using the particular structure of the steady states. This is joint work with Luan Hoang and Akif Ibragimov.

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MS68

Complementary Media in Metamaterials

In this talk, I will discuss the frame work of complementary media in metamaterials. Resonant and localized resonant phenomena will be discussed. Applications in cloaking will be given.

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MS68

On Passage to the Limit in Nonlinear Elliptic and Parabolic Equations

Passing to the limit in nonlinear terms one encounters the fundamental problem of "weak convergence of fluxes to a flux". The term "flux" refers to the vector $A(x, \nabla u_\varepsilon)$ which stands in the elliptic equation under the divergence sign. Usually one has the weak convergence $u_\varepsilon \rightharpoonup u$ in some Sobolev space and the weak convergence of the fluxes $A(x, \nabla u_\varepsilon) \rightharpoonup z$ in some Lebesgue space. This leads to the problem of the equality $z = A(x, \nabla u)$. Let us state one result in this direction. Assume that 1. $u_\varepsilon \rightharpoonup u$ in $W^{1,\alpha}(\Omega)$, $\alpha > 1$; 2. The symbol A is monotone:

$$(A(x, \xi) - A(x, \eta)) \cdot (\xi - \eta) \geq 0;$$

3. $\mathrm{div} A(x, \nabla u_\varepsilon) = 0$ in the sense of distributions,

$$A_\varepsilon \equiv A(x, \nabla u_\varepsilon) \rightharpoonup z \text{ in } L^{\beta'}(\Omega), \quad \beta' = \frac{\beta}{\beta - 1};$$

4. $1 < \alpha \leq \beta < \alpha_*$,

$$\alpha_* = \begin{cases} \frac{\alpha(N-1)}{N-1-\alpha} & \text{for} \quad \alpha < N-1, \\ +\infty & \text{for} \quad \alpha \geq N-1; \end{cases}$$

5. The family of "energy densities" $A_\varepsilon \cdot \nabla u_\varepsilon$ is bounded in $L^1(\Omega)$; 6. $u_\varepsilon \in W^{1,\beta}(\Omega)$ (additional regularity of prelimit functions). Then $z = A(x, \nabla u)$. (Note that in the classical case when $\alpha = \beta$ the last three conditions hold automatically.) In this talk we will discuss the following applications: monotone elliptic operators with nonstandard growth conditions; thermistor problem; and generalized Navier-Stokes equations.

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MS69

A Blob Method for the Aggregation Equation

In the past five to ten years, there has been substantial activity on the theory of the aggregation equation, but comparatively little on the analysis of numerical methods. In this talk, I will present joint work with Andrea Bertozzi on a blob method for the aggregation equation, inspired by vortex blob methods from the classical fluids case.

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MS69

Nonlinear Stability of Steady States of Nonlocal-interaction Equations

We will discuss stability of steady states of the nonlocal-interaction equations. The problem is considered in the space of measures. Numerical experiments show that stable steady states of nonlocal interaction equations can exhibit a wide array of patterns. Recent works also show that for smooth potentials the energy minimizers are supported on set of dimension less than one. We will discuss rigorous results on the stability of steady states for smooth potentials. The main focus is on (local) minimizers which are sums of delta masses. We establish sufficient conditions for the nonlinear stability to hold. The criteria are based on extended notion of linear stability, which allows for splitting of the particles, and can be verified for a number of steady states.

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MS69

Title Not Available at Time of Publication

Abstract not available at time of publication.

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MS69

Nonlocal Interaction Equations in Environments with Heterogeneities and Boundaries

In this presentation, we discuss biological aggregation in a heterogeneous environment by modeling the environment as a Riemannian manifold with boundary. We develop gradient flow approach in the space of probability measures on the manifold endowed with Riemannian 2-Wasserstein metric. We then show the existence and stability of weak measure solutions to a class of nonlocal interaction equations through the gradient flow approach. We discuss how heterogeneity of the environment leads to new dynamical phenomena. In particular exposed to a unidirectional external potential the agents form a rolling travelling wave (in contrast to the translational motion in the homogeneous environment). We close the presentation by giving some simulations to show the rolling phenomenon.

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MS70

Liquid Crystals: from Molecular Dynamics to Pdes

Abstract not available at time of publication.

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MS70

Field Responses of Smectic A Liquid Crystals in 2D and 3D

We study the Landau-de Gennes free energy to describe the undulatory instability in smectic A liquid crystals subjected to magnetic fields. At the onset of undulations close to the critical field, the periodic oscillation occurs. We prove this phenomena by the bifurcation theory to the nonlinear system of Landau-de Gennes model. We also find the critical field and oscillatory description at the onset of the undulations. When the applied field is sufficiently large, the director lies in the direction either positive or negative field assuming the natural boundary condition on the smectic order parameter is imposed. We also perform numerical simulations to illustrate the results of our analysis. Undulation instabilities on three dimensional systems will be also discussed.

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MS70

The Existence of Global Solutions to the Ericksen-Leslie System in R^2

In this talk, I will discuss the regularity and existence of global weak solution of the general Ericksen-Leslie system in dimension two under a set of condition of Leslie coefficients, which assure that the total energy is decreasing under the flow. This is based on joint work with Jinrui

Huang and Fanghua Lin.

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MS70

Models for Active Liquid Crystals and Their Applications to Complex Biological Systems

Abstract not available at time of publication.

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MS71

The Wiener Test for the Removability of the Logarithmic Singularity for the Elliptic PDEs with Measurable Coefficients, and Its Measure-Theoretical, Topological, and Probabilistic Consequences

This talk introduces a notion of *log*-regularity (or *log*-irregularity) of the boundary point ζ (possibly $\zeta = \infty$) of arbitrary open subset Ω of the Greenian deleted neigborhood of ζ in R^2 concerning second order uniformly elliptic equations with bounded and measurable coefficients, according as whether the *log*-harmonic measure of ζ is null (or positive). A necessary and sufficient condition for the removability of the logarithmic singularity, that is to say for existence of a unique solution to the Dirichlet problem in Ω in a class of solutions with possibly logarithmic growth rate at ζ, is established in terms of the Wiener test for the *log*-regularity of ζ. From the topological point of view, the Wiener test at ζ presents minimal thinness criteria of sets near ζ in minimal fine topology. Precisely, the open set Ω is a deleted neigbourhood of ζ in minimal fine topology if and only if ζ is *log*-irregular. From the probabilistic point of view Wiener test presents asymptotic law for the *log*-Brownian motion near ζ conditioned on the logarithmic kernel with pole at ζ.

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MS71

The Elliptic Obstacle Problem When the Coefficients Are Only in Vmo

We study the elliptic obstacle problem in both divergence and nondivergence form. In both cases, although we can show a measure theoretic version of Caffarelli's Theorem from his famous 1977 Acta paper, we can also give examples of nonuniqueness in blowup limits.

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MS71

Monotonicity Formulas in the Signorini Problem

We will discuss some new monotonicity formulas which play a crucial role in the study of the Signorini problem.

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MS71

On a Thermodynamically Consistent Stefan Problem with Variable Surface

A thermodynamically consistent two-phase Stefan problem with temperature-dependent surface tension and with or without kinetic undercooling is studied. It is shown that these problems generate local semiflows in well-defined state manifolds. If a solution does not exhibit singularities, it is proved that it exists globally in time and converges towards an equilibrium of the problem. In addition, stability and instability of equilibria is studied. In particular, it is shown that multiple spheres of the same radius are unstable if surface heat capacity is small; however, if kinetic undercooling is absent, they are stable if surface heat capacity is sufficiently large. (Joint work with J. Prüss and M. Wilke).

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MS72

Modeling Arterial Walls As a Multi-Layered Structure, and Their Interaction with Pulsatile Blood Flow

We study the interaction between an incompressible, viscous fluid and a multilayered structure, which consists of a thin and a thick elastic layer. The thin layer is modeled using the linearly elastic Koiter shell model, while the thick layer is modeled using the 2D equations of linear elasticity. The system is coupled via the kinematic and dynamic coupling conditions. We present a loosely-coupled numerical algorithm, and stability results. The results will be supported with numerical examples.

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MS72

Validation of An Open Source Framework for the

Simulation of Blood Flow in Deformable Vessels

We discuss in the validation of an open source framework for the solution of problems arising in hemodynamics. The framework is assessed through a numerical benchmark dealing with the propagation of a pressure wave in a fluid-filled elastic tube. The computed pressure wave speed and frequency of oscillations, and the axial velocity of the fluid on the tube axis are close to the values predicted by the analytical solution associated with the benchmark.

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MS72

Reduced Models for Solving Inverse Fluid-Structure Interaction Problems

We are interested in solving the data assimilation problem: given the displacement of a pipe where an incompressible fluid flows, identify the wall compliance (Young modulus E). We resort to a variational approach. E is regarded as control variable in the minimization of the mismatch between measured and computed displacement. In solving this inverse fluid-structure interaction problem, we face formidable computational costs. We resort to reduced models based on a Proper Orthogonal Decomposition approach.

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MS72

Enforcing Interface Conditions for Fsi Problems Using Nitsche's Method. Derivation of Explicit Coupling Strategies for Multilayered Poroelastic Arteries.

Nitsche's method was developed to weakly enforce Dirichlet boundary conditions for PDEs approximated with FEM. Recently, it has been applied to the transmission conditions of fluid-structure interaction (FSI) problems. It provides a general framework capable to accommodate strongly and loosely coupled schemes. We apply it to design FSI algorithms for multilayered poroelastic arteries. We will combine the analysis of the equations with direct simulations to understand how poroelasticity affects blood flow in arteries.

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MS73

Singular Limits of Compressible Fluids

We discuss several singular limits arising in the scale analysis of the Navier-Stokes(-Fourier) system describing the motion of a general compressible, viscous, (and heat conducting) fluid. We consider rapidly rotating stratified fluids in the incompressible and/or inviscid limit. The effect of simultaneous scalings is considered. To this end, we use the concept of relative entropy, together with careful analysis of certain oscillatory integrals arising in the study of Poincaré waves.

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MS73

Compressible Navier-Stokes System with Inflow Condition

I will talk about the issue of stability of Poiseuille type flows in regime of compressible Navier-Stokes equations in a three dimensional finite pipe-like domain. We prove the existence of stationary solutions with inhomogeneous Navier slip boundary conditions admitting nontrivial inflow condition in the vicinity of constructed generic flows. Our techniques are based on an application of a modification of the Lagrangian coordinates. Thanks to such approach we are able to overcome difficulties coming from hyperbolicity of the continuity equation, constructing a maximal regularity estimate for a linearized system and applying the Banach fixed point theorem. The talk is based on the joint result with Tomasz Piasecki.

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MS73

Well-Posedness of the Primitive Equations of the Ocean with Continuous Initial Data

We address the well-posedness of the primitive equations of the ocean with continuous initial data. We show that the splitting of the initial data into a regular finite energy part and a small bounded part is preserved by the equations thus leading to existence and uniqueness of solutions.

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MS73

Existence Analysis of the Navier-Stokes System for Multicomponent Mixtures

We will present a model of motion of compressible, heat-conducting mixture of arbitrary large number of species. We consider a special form of density-dependent viscosity coefficients and a singular behaviour of the cold component of the internal pressure near vacuum. Under these hypotheses we prove global-in-time existence of weak solutions. This result is based on several joint papers with P.B. Mucha and M. Pokorný.

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MS74

Pde Model of Gbm: Insights Into The Shortcomings of Anti-Angiogeneic Therapy

The recent use of anti-angiogenesis (AA) drugs for the treatment of glioblastoma multiforme (GBM) has uncovered unusual tumor responses. Here, we derive a new mathematical model that takes into account the ability of proliferative cells to become invasive under hypoxic conditions; model simulations generate the multilayer structure of GBM, namely proliferation, brain invasion, and necrosis. The model is validated by replicating and justifying the clinical observation of rebound growth when AA therapy is discontinued in some patients. The model is interrogated to derive fundamental insights in cancer biology and on the clinical and biological effects of AA drugs. Invasive cells promote tumor growth, which in the long-run exceeds the effects of angiogenesis alone. Furthermore, AA drugs increase the fraction of invasive cells in the tumor, which explain progression by FLAIR and the rebound tumor growth when AA is discontinued.

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MS74

On the Euler-Poincare Equation with Non-Zero Dispersion

The Euler-Poincare equation was introduced by Holm, Marsden and Ratiu to study ideal fluids with nonlinear dispersion. It can be viewed as a natural multi-dimensional generalization of the popular Camassa-Holm equations. I will discuss some recent results on the sharp characterization of a special family of solutions based on some new inverse-Soblev type inequalities. In particular this settles an open problem raised by Chae and Liu.

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MS74

Laminar Boundary Layers in Rayleigh-Benard Convection

We study Rayleigh-Benard convection in the high-Rayleigh-number and infinite-Prandtl-number regime. While the dynamics in the bulk are characterized by a chaotic convective heat flow, the boundary layers at the horizontal container plates are essentially conducting and thus the fluid is motionless. Consequently, the average temperature exhibits a linear profile in the boundary layers. In this talk, I present new rigorous local bounds on temperature field and fluid velocity in the boundary layers, and show that the temperature profile is indeed essentially linear. All results are uniform in the system parameters (e.g. the Rayleigh number) up to logarithmic correction terms.

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MS75

Weak Solutions for Pressureless Gas Dynamics and Other Hyperbolic Systems Through Energy Minimization

We introduce a new and very simple method to obtain weak solutions to some hyperbolic problems, including gas dynamics in dimension 1 (any gamma between 1 and 3) and pressureless gas dynamics in any dimension. The method itself simply consists in minimizing the kinetic energy over the considered time interval with appropriate constraints.

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MS75
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Abstract not available at time of publication.

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MS75
Incompressible Limits for Magnetohydrodynamics

Incompressible limits for magnetohydrodynamics will be discussed. In particular, the zero Mach limit and the hydrodynamic limit will be presented.

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MS75
Convex Entropy, Hopf Bifurcation, and Viscous and Inviscid Shock Stability

We discuss relations between one-dimensional inviscid and viscous stability/bifurcation of shock waves in continuum-mechanical systems and existence of a convex entropy. In particular, we show that the equations of gas dynamics admit equations of state satisfying all of the usual assumptions of an ideal gas, along with thermodynamic stability- i.e., existence of a convex entropy- yet for which there occur unstable inviscid shock waves. For general 3x3 systems (but not up to now gas dynamics), we give numerical evidence showing that viscous shocks can exhibit Hopf bifurcation to pulsating shock solutions. Our analysis of inviscid stability in part builds on the analysis of R. Smith characterizing uniqueness of gas dynamical Riemann solutions in terms of the equation of state of the gas, giving an analogous criterion for stability of individual shocks.

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MS76
Coherent Structures of a Nonlocal FitzHugh-Nagumo Equation

We prove the existence of coherent structures for a class of FitzHugh-Nagumo equations with nonlocal diffusion. Unlike the dynamical systems approach via geometric singular perturbation theory (Fenichel's theorem and Exchange Lemma), our proof relies on matched asymptotics techniques and Fredholm properties of differential operators on suitable Banach spaces (Spectral Flow and Nonlocal Exchange Lemma).

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MS77
Deterministic Solvers to Describe DG-MOSFET Devices

Statistical models are used to describe electron transport in semiconductors at a mesoscopic level. The basic model is given by the Boltzmann transport equation for semiconductors in the semi-classical approximation coupled with Poissons equation, since the electric ?eld is self-consistent due to the electrostatics produced by the electrons and the dopants in the semiconductor. However, for short devices, this mathematical description has to be modified, since the electrons behave as particles along the long dimension, and as waves along the short dimension. In these cases, the devices can be modelled by the Boltzmann-Schrdinger-Poisson system. In this talk we show deterministic solvers to describe long and short Double Gate Metal Oxide Semiconductor Field E?ect Transistors (DG-MOSFET) devices.

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MS77
Charge Transport in Bulk-Heterojunction Organic Solar Cells: Adaptivity, High-Throughput Computing and Optimal Morphologies

Abstract not available at time of publication.

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MS77
Multiscale Modeling and Computation of Nano Optical Responses

We introduce a new framework for the multiphysical modeling and multiscale computation of nano-optical responses. The semi-classical theory treats the evolution of the electromagnetic field and the motion of the charged particles self-consistently by coupling Maxwell equations with Quantum Mechanics. To overcome the numerical challenge of solving high dimensional many body Schrodinger equations involved, we adopt the Time Dependent Current Density Functional Theory (TD-CDFT). In the regime of linear responses, this leads to a linear system of equations determining the electromagnetic eld as well as the current and electron densities simultaneously. A self-consistent multiscale method is proposed to deal with the well separated space scales. Numerical examples are presented to illustrate the resonant condition.

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MS77

First-Principles Prediction of Charge and Energy Transport in Disordered Semiconductors for Photovoltaic Applications

Abstract not available at time of publication.

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MS78

Homogenization for Problems with Oscillatory Boundary Conditions

In this talk I will discuss two new homogenization results, one concerning a growing free boundary in a randomly perforated domain (with Inwon Kim) and another dealing with a fully nonlinear Neumann problem with periodic data (with Russell Schwab). In both instances, the main result is that the oscillations of the boundary data or of the random perforations resolve themselves in such a way that the problems converge in the high frequency limit to a deterministic and homogeneous problem. Although both problems are of a very different nature, their broad analysis centers on two key themes: the derivation of uniform pointwise estimates and the identification of an effective equation via auxiliary correctors. In the case of the fully nonlinear Neumann problem, the effective equation at the boundary can be identified thanks to a new representation formula for nonlinear operators enjoying a global comparison principle.

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MS78

Anomalous Spreading in a System of Coupled Fisher-Kpp Equations

This talk will concern anomalous spreading in a system of reaction-diffusion equations. When a single parameter is set to zero the system consists of a pair of uncoupled Fisher-KPP equations. Anomalous spreading occurs when one component of the system spreads at a faster speed in the coupled system than it does in isolation, while the speed of the second component remains unchanged. We will discuss the role of the pointwise Green's function in anomalous spreading and discuss mechanisms leading to anomalous spreading in both the linear and nonlinear regime.

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MS78

The Logarithmic Delay of Kpp Fronts in a Heterogeneous Medium

I'll describe the asymptotic behavior of solutions to a reaction-diffusion equation with KPP-type nonlinearity. One can interpret the solution in terms of a branching Brownian motion. It is well-known that solutions to the Cauchy problem may behave asymptotically like a traveling wave moving with constant speed. On the other hand, for certain initial data, M. Bramson proved that the solution to the Cauchy problem may lag behind the traveling wave by an amount that grows logarithmically in time. Using PDE arguments, we have extended this statement about the logarithmic delay to the case of periodically varying reaction rate. We also consider situations where the delay is larger than logarithmic. This new PDE approach involves the study of the linearized equation with Dirichlet condition on a moving boundary.

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MS78

Sharp Asymptotic Growth Laws of Turbulent Flame Speeds in Cellular Flows by Inviscid Hamilton-Jacobi Models

To determine the turbulent flame speed is a fundamental problem in turbulent combustion. A specific project is to understand its growth law with respect to the flow intensity. In this talk, we will present the sharp growth law of turbulent flame speed in two dimensional cellular flows predicted by a model proposed by Majda and Souganidis in 90's. This answers an open problem posed in a paper by Embid, Majda and Souganidis.

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MS79

Landis-type Lemma of Growth in the Layered Cylinders for Solution of the Parabolic Degenerate Equation and Applications

We will consider a parabolic equation of second order in unbounded domain with Dirichlet type boundary conditions. Corresponding operator can degenerate at infinity with respect to x and t. Lemma of growth will be proved for class of the solution of the equation in layered cylinder. Using

this Lemma we will prove parabolic analog *Phragmén-Lindelöf* type principle in x and t directions.

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MS79

An Ersatz Existence Theorem for Fully Nonlinear Parabolic Equations without Convexity Assumptions

We show that for any uniformly parabolic fully nonlinear second-order equation with bounded measurable "coefficients' and bounded "free' term in the whole space or in any cylindrical smooth domain with smooth boundary data one can find an approximating equation which has a continuous solution with the first and the second spatial derivatives under control: bounded in the case of the whole space and locally bounded in case of equations in cylinders. The approximating equation is constructed in such a way that it modifies the original one only for large values of the second spatial derivatives of the unknown function. This is different from a previous work of Hongjie Dong and the author where the modification was done for large values of the unknown function and its spatial derivatives.

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MS79

Ultrasound-modulated Optical Tomography: A Nonlinear Model

Let Ω be an optical body with several obstacles and let a_* denote the unknown absorption coefficient of Ω. Such obstacles can be imaged using the knowledge of a_*. In this talk, by using near-infrared light to illuminate Ω and spherical acoustic waves to purturb Ω, we can establish a nonlinear equation for a_*. This equation can be solved by applying the optimal control method.

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MS79

A New Curvature-dependent Surface Tension Model in Fracture Mechanics

A new approach to modeling of a brittle fracture based on an extension of a continuum mechanics to the nanoscale will be considered. The classical Neumann boundary condition on the fracture surface is augmented with a curvature-dependent surface tension. The model is studied on an example of a plain-strain mixed mode fracture. Using complex variable methods, the mechanical problem is reduced to a system of coupled Cauchy singular integro-differential equations. The regularization and the numerical solution of this system is considered. It is shown that incorporation of a curvature- dependent surface tension into fracture modeling eliminates the integrable crack-tip stress and strain singularities of order 1/2 present in the classical linear fracture mechanics solutions. Directions for the future research in this area will be presented.

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MS80

Global Regularity for Some Oldroyd-B Type Models of Viscoelasticity

We investigate some critical models for visco-elastic flows of Oldroyd-B type in dimension two. We use a transformation which exploits the Oldroyd-B structure to prove an L^∞ bound on the vorticity which allows us to prove global regularity for our systems. This is a joint work with Frederic Rousset

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MS80

Title Not Available at Time of Publication

Abstract not available at time of publication.

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MS80

The Numerical Approach of the Singularly Perturbed Problems

In this talk, I will present the numerical solutions of singularly perturbed problems in a circular domain and provide as well approximation schemes, error estimates and numerical simulations. To resolve the oscillations of classical numerical solutions due to the stiffness of our problem, we construct, via boundary layer analysis, the so-called boundary layer elements which absorb the boundary layer singularities. Using a P1 classical finite element space enriched with the boundary layer elements, we obtain an accurate numerical scheme in a quasi-uniform mesh. The talk includes a joint work with C.-Y. Jung and R. Temam.

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MS80

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Abstract not available at time of publication.

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MS81

Magic Toplitz Matrix for Mixed Boundary Laplace Equation and Its Application to Breast Cancer Detection

Laplace equation naturally arises in modeling of electrical properties of the media and can be used to recover conductivity and permittivity inside the body through measurement of currents and voltages on the periphery of the body. In electrical impedance tomography (EIT), currents are injected through the electrodes located on the boundary of the body with no current between electrodes which leads to a mixed boundary value problem. The inverse problem on the reconstruction of conductivity and permittivity at each point inside the body is multidimensional and ill-posed. We suggest that for cancer detection/screening one needs to prove that the breast tissue is non-homogeneous. This leads to the problem of derivation of the exact solution of the Laplace equation with mixed-type boundary conditions (Robin-type on the electrodes and Neumann-type between electrodes). Under simplifying assumption, this solution is derived for the disk that gives rise to Magic Toeplitz (circulant) matrix which can be viewed as a Dirichlet-to-Neumann map, or in the context of physics as a generalization of the Ohms law on the disk. It is shown that the elements of the Magic Toeplitz matrix can be represented through new special function that is expressed via Fourier integral or series. We apply Magic Toeplitz matrix to detect bad electrode contact on the breasta typical problem of EIT in a clinical setting.

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MS81

On the Optimal Control of Free Boundary Boundary Problems for the Second Order Parabolic PDEs

We develop a new variational formulation of the inverse Stefan problem, where information on the heat flux on the fixed boundary is missing and must be found along with the temperature and free boundary. We employ optimal control framework, where boundary heat flux and free boundary are components of the control vector, and optimality criteria consists of the minimization of the sum of L_2-norm declinations from the available measurement of the temperature flux on the fixed boundary and available information on the phase transition temperature on the free boundary. This approach allows one to tackle situations when the phase transition temperature is not known explicitly, and is available through measurement with possible error. It also allows for the development of iterative numerical methods of least computational cost due to the fact that for every given control vector, the parabolic PDE is solved in a fixed region instead of full free boundary problem. We prove well-posedness in Sobolev spaces framework and convergence of discrete optimal control problems to the original problem both with respect to cost functional and control.

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MS81

Recent Progress on Local Behavior of the Logarithmic Diffusion Equation

This talk describes some recent progress on the local behavior of the equation $u_t = \Delta \ln u$ including a Harnack-type inequality, L^1 form Harnack inequality and local special analyticity. Connection with the porous medium equation $u_t = \Delta(u^m/m)$ and stability of all the estimates as m tends to 0 is presented.

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MS81

Title Not Available at Time of Publication

Abstract not available at time of publication.

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MS82

Kinetic Formulation and Regularizing Effects for Degenerate Parabolic Equations

In this talk, we present how to obtain regularity of solutions to degenerate parabolic equations. The main idea is to identify the renormalization property of solutions from the structure of the nonlinearity. We then apply the velocity averaging to their underlying kinetic formulations, which leads to the regularizing effect of solutions. Our results extend previous regularity statements and provide a new regularity result of renormalized solutions.

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MS82

Critical Regularity Estimates for Transport Problems

A new method to obtain regularity for solutions to transport equations is introduced. This is applied to problems in biology (such as some chemotaxis models) but also to compressible fluid dynamics where it significantly extends the existing existence theory (non monotone pressure terms, temperature dependent viscosity... In addition of providing compactness for the macroscopic density, the method also yields explicit, critical regularity estimates.

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MS82

Regularizing Effects on 1D Nonlinear Scalar Conservation Laws in Fractional Bv Spaces

In 1D, fractional BV spaces are introduced to obtain smoothing effects for conservation laws. Theses spaces have trace properties like BV . This is not the case for Sobolev spaces with similar regularity. For nonlinear degenerate convex fluxes the optimal smoothing effect is proven. Some hints will be given on the non convex case. The important notion of nonlinear flux will be discussed. Furthermore, the fractional BV regularity implies the maximal regularity conjectured by Lions-Perthame-Tadmor in 1994.

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MS82

Dissipation Vs. Quadratic Nonlinearity: from Energy Bound to High-Order Regularizing Effect

We consider a general class of evolutionary PDEs involving dissipation (of possibly fractional order), which competes with quadratic nonlinearities on the regularity of the overall equation. This includes the prototype models of Burgers' equation, Navier-Stokes equations, the surface quasi-geostrophic equations and the Keller-Segel model for chemotaxis. Here we establish a Petrowsky type parabolic estimate of such equations which entail a precise time decay of higher-order Sobolev norms for this class of equations. To this end, we introduce as a main new tool, an "infinite order energy functional', $E(t) := \sum_n a_n t^n \|(-\Delta)^{n\theta/2} u(*,t)\|_{L^2}$, which captures the regularizing effect of *all* higher order derivatives of $u(*,t)$, by proving — for a carefully, problem-dependent choice of weights $\{a_n\}$, that $E(t)$ is non-increasing in time.

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MS83

Nonlinear Diffusion Equation Model of Bacterial Dynamics

Abstract not available at time of publication.

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MS83

Fully Anisotropic Diffusion Equations and Applications to Glioma Growth and Wolf Movement

Abstract not available at time of publication.

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MS83

Scale Invariance in Mathematical Models of Biological Pattern Formation

Abstract not available at time of publication.

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MS83

Local Kinetics of Morphogen Gradients

Abstract not available at time of publication.

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MS84

Regularity and Uniqueness for a Class of Weak Solutions to the Hydrodynamic Flow of Nematic Liquid Crystals

We establish an ϵ-regularity criterion for any weak solution (u, d) to the nematic liquid crystal flow such that $(u, \nabla d) \in L_t^p L_x^q$ for some $p \geq 2$ and $q \geq n$ satisfying the condition $\frac{n}{q} + \frac{2}{p} = 1$. As consequences, we prove the interior smoothness and uniqueness of any such a solution when $p > 2$ and $q > n$.

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MS84

Existence and Decay of Solutions of the 2dqg Equa-

tion in the Presence of An Obstacle

We study the 2D dissipative quasi-geostrophic equation in the presence of an obstacle, where the dissipative term is given by a fractional power of the Laplacian. Our main tools are the generalized Fourier transform due to Ikebe and Ramm, and the localized version of the fractional Laplacian due to Caffarelli and Silvestre as improved by Stinga and Torrea. We give applications to the problem of existence of weak solutions and the decay of these solutions in the L^2-norm.

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MS84

Dynamical Aspects of the Cubic Instability in a Landau-De Gennes Energy for Nematic Liquid Crystals

We consider a four-elastic-constant Landau-de Gennes energy characterizing nematic liquid crystal configurations. It is known that certain physical considerations require the presence of a cubic term, which nevertheless makes the energy unbounded from below. We study the dynamical effects produced by the presence of this cubic term by considering the L^2 gradient flow generated by this energy. We work mostly in dimension two and our objective is to provide an understanding of the relations between the physicality of the initial data and the global well-posedness of the system.

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MS84

Regularizing Effect of the Forward Energy Cascade in the Inviscid Dyadic Model

We study the inviscid dyadic model of the Euler equations and prove some regularizing properties of the nonlinear term that occur due to forward energy cascade. This leads to several regularity results the inviscid case. We conjecture that every blow up has Onsager's scaling and discuss recent progress toward achieving this goal.

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MS85

Well-Posedness for Variational Wave Equations

We discuss the singularity formation, global existence and uniqueness for energy conservative solutions for variational wave systems from modelling nematic liquid crystals and other models. Gradient blowup happens in general for solutions in these systems, which causes the major difficulty. Especially, a recent progress got with Alberto Bressan on the uniqueness of energy conservative solution for a variational wave equation

$$u_{tt} - c(u)\Big(c(u)\,u_x\Big)_x = 0, \quad \text{with} \quad 0 < C_1 < c(u) < C_2,$$

by finding a Lipschitz continuous Finsler metric through the optimal mass transformation method is a groundbreaking work for nonlinear hyperbolic equations. This presentation also includes collaboration works with Ping Zhang and Yuxi Zheng.

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MS85

Boussinesq System with Nonlinear Heat Diffusion on a Bounded Domain

On a bounded 2D domain with smooth boundary, we prove the global existence of a unique smooth solution to the inviscid heat conductive Boussinesq Equations with nonlinear diffusion, along with homogeneous Dirichlet boundary condition for temperature and slip boundary condition for velocity. Such a solution is also shown to be the vanishing viscosity limit for the corresponding viscous and heat conductive Boussinesq equation with the same boundary condition for temperature, and Navier boundary condition for the velocity. This talk is based on the joint work with Huapeng Li, Hongjun Yuan, and Weizhe Zhang.

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MS85

Title Not Available at Time of Publication

Abstract not available at time of publication.

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MS85

Conservation Laws with no Classical Riemann Solutions: Existence of Singular Shocks

The basic tool in the construction of solutions to the Cauchy problem for conservation laws with smooth initial data is the Riemann problem. We review the results obtained for the solutions to the Riemann problem and present a system of two equations derived from isentropic gas dynamics with no classical solution. We then use the blowing-up approach to geometric singular perturbation problems to show that the system exhibits unbounded solutions (singular shocks) with Dafermos profiles.

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MS86

Competitive Geometric Evolution of Complex Structures in Fuel Cell Membranes

Surfactant molecules are amphiphilic: composed of a hydrophilic and a hydrophobic moiety. When mixed with a wettable material the amphiphilic component forms molecular-width bilayer interfaces and pore structures which interpenetrate the bulk regions of the second phase. These structures are manifest as pore networks in blends of functionalized polymer and solvent, and lipid-filled cellular membranes in biological settings. The competition for the surfactant phase generates interfacial dynamics fundamentally different from those obtained in mixtures of mutually hydrophobic phases. Using the Functionalized Cahn-Hilliard free energy as a model for amphiphilic mixtures, we employ a multiscale analysis to derive the curvature driven flow of smooth closed bilayers and closed-loop pore structures, which we extend to a sharp-interface reduction for the competitive evolution of collections of bilayer interfaces and closed-loop pores. In particular, for a mixture of spherical bilayers and circular closed pores we explicitly identify two regimes: one in which spherical bilayers extinguish and the circular pores arrive at a common radius, and a complimentary regime in which spherical bilayers of differing radii stably coexist with common-radius, closed-loop, circular pores.

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MS86

Master Equation Model for Charge Transport in Disordered Semiconductors

Charge transport plays a key role in the performance of bulk heterojunction solar cells. This type of solar cells contains a mixture of donor and acceptor molecular species with a certain degree of phase segregation. I will present a Pauli master equation model for the charge transport in these systems and address how the charge mobility is affected by the energy offset between the transporting levels of the two molecular species, the partial volume occupied by each species and their typical domain size. Our results also pertains partially crystalline samples made of a single material.

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MS86

Hall-Mhd and Related Plasma Problem

In this talk, I will present some derivations and analysis of the the Hall Magneto-Hydrodynamic equations. We first provide a derivation of this system from a two-fluids Euler-Maxwell system for electrons and ions, through a set of scaling limits. We also propose a kinetic formulation for the Hall-MHD equations which contains as fluid closure different variants of the Hall-MHD model. Then, we will present some well-poseness results for the incompressible resistive Hall-MHD model, including global weak solutions, local existence of smooth solutions for large data, global smooth solutions for small datas well, as a Liouville theorem for the stationary solutions. We use the particular structure of the Hall term which has zero contribution to the energy identity. Finally, we discuss particular solutions in the form of axisymmetric purely swirling magnetic fields and propose some regularization of the Hall equation.

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MS87

Eventual Self-Similarity of Solutions for Diffusion-Absorption Equation with a Singular Source

We consider a class of diffusion-absorption equations with a singular source in $\mathbf{R}^{\mathbf{n}}$. We establish existence of a weak self-similar solutions for these equations which arise in a limit of an infinitely strong singular source. We prove uniqueness of such solution in a suitable weighted energy spaces. Moreover, we show that the obtained self-similar solutions are the long-time limits of the solutions of the initial value problem for considered class of diffusion-absorption problems with zero initial data and a singular source of arbitrary constant strength. This is a joint work with Cyrill Muratov.

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MS87

Front Propagation in Sharp and Diffuse Interface Models of Stratified Media

We study front propagation problems for forced mean curvature flows and their phase field variants that take place in stratified media, i.e., heterogeneous media whose characteristics do not vary in one direction. We consider phase change fronts in infinite cylinders whose axis coincides with the symmetry axis of the medium. Using the recently developed variational approaches, we provide a convergence result relating asymptotic in time front propagation in the diffuse interface case to that in the sharp interface case for suitably balanced nonlinearities of Allen-Cahn type. The result is established by using Γ-convergence type arguments to obtain a correspondence between the minimizers of an exponentially weighted Ginzburg-Landau-type functional and the minimizers of an exponentially weighted area-type functional. These minimizers yield the fastest moving traveling waves in the respective models and determine the asymptotic propagation speeds for front-like initial data. We further show that generically these fronts are the exponentially stable global attractors for this kind

of initial data and give sufficient conditions under which complete phase change occurs via the formation of the considered fronts.

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MS87

Quasi-Static Evolution and Congested Crowd Motion

In this talk we investigate a transport equation with a drift potential, where a constraint on the L^∞ norm is imposed on the density. This model, in a simplified setting, describes the congested crowd motion with a density constraint. When the drift potential is convex, the crowd density is likely to aggregate, and thus if the initial density starts as a patch (i.e. if it is a characteristic function of some set), then the density evolves like a patch. We show that patch evolves according to a quasi-static evolution equation, which is a free boundary problem and has some connection with the Hele-Shaw equation. To show this result we make use of both viscosity solutions theory as well as the gradient flow structure of the problem.

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MS87

Discrete Motion by Mean Curvature

We will discuss some results on the motion of interfaces in a discrete environment. The model takes into account nearest and next nearest neighbor spin interactions leading to interfaces between patterns. Intricate stick-slip phenomena also arises through different spatial and temporal discretization. This is joint work with Andrea Braides and Marco Cicalese.

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MS88

Well-Posedness and Asymptotic Stability for the Lame System with Infinite Memories in Bounded Domain

In this work, we consider the Lame system in 3-dimension bounded domain with infinite memories. We prove, under some appropriate assumptions, that this system is well posed and still stable, and we get a general and precise estimate on the convergence of solutions to zero at infinity in term of the growth of the infinite memories.

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MS88

Vanishing Viscosity Limit of Some Symmetric Flows

Abstract not available at time of publication.

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MS88

Singular Perturbation Analysis for Convection-diffusion Equations with Corners

We study the asymptotic behavior at small diffusivity of the solutions to a convection-diffusion equation in a rectangular domain ?. The diffusive equation is supplemented with a Dirichlet boundary condition, which is smooth along the edges and continuous at the corners. To resolve the discrepancy between the exact solutions and the corresponding limit solution on the boundaries, we propose asymptotic expansions of at any arbitrary, but fixed, order. In order to manage some singular effects near the four corners of ?, the so-called elliptic and ordinary corner correctors are added in the asymptotic expansions as well as the parabolic and classical boundary layer functions. Then, performing the energy estimates on the difference of the exact solutions and the proposed expansions, the validity of our asymptotic expansions is established in suitable Sobolev spaces.

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MS88

How Do Flows in Conduit and Porous Media Interact?

Multiphase flow phenomena are ubiquitous. Common examples include coupled atmosphere and ocean system (air and water), oil reservoir (water, oil and gas), cloud and fog (water vapor, water and air). Multiphase flows also play an important role in many engineering and environmental science applications. In some applications such as flows in unconfined karst aquifers, karst oil reservoir, proton membrane exchange fuel cell, multiphase flows in conduits and in porous media must be considered together. How free flows in conduit/channel interact with flow in porous media is a challenge. In this talk we present a family of phase field models that couples two phase flow in conduit with two phase flow in porous media. These models together with the associated interface boundary conditions are derived utilizing Onsager's extremum principle. The models derived enjoy physically important energy law. Numerical scheme that preserves the energy law will be presented as well.

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