IP1

Nonconvex Hamilton-Jacobi Equations

The Crandall–Lions theory of viscosity solutions provides existence and uniqueness theory for appropriate weak solutions Hamilton–Jacobi type PDE, but does not for nonconvex Hamiltonians directly provide much information about the structure of solutions, their possible singularities, etc. I will report on some recent work on nonconvex Hamilton–Jacobi equations, explaining how to apply geometric insights, compensated compactness tricks and game theoretic methods to such PDE. I will in particular revisit some examples from the great book of Isaacs on differential games.

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IP2

Title Not Available at Time of Publication

Abstract not available at time of publication.

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IP3

Nonlocal Evolution Equations

Nonlocal evolution equations have been around for a long time, but in recent years there have been some nice new developments. The presence of nonlocal terms might originate from modeling physical, biological or social phenomena (incompressibility, Ekman pumping, chemotaxis, micro-micro interactions in complex fluids, collective behavior in social aggregation) or simply from inverting local operators in the analysis of systems of PDE. I will present some regularity results for hydrodynamic models with singular constitutive laws. I will also present a nonlinear maximum principle for linear nonlocal dissipative operators and some applications.

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IP4

Mathematical and Numerical Modelling of the Respiratory System

The respiratory system is a complex multiphysics and multiscale system. Indeed, breathing involves gas transport through the respiratory tract: the inhaled air is convected in the fractal bronchial tree which ends in the alveoli embedded in a viscoelastic tissue, made of blood capillaries, and where gaseous exchange occurs. Inhaled air contains dust and debris or curative aerosols. In this talk we present some mathematical and numerical modelling issues related to this system. Many questions may be addressed, such as the wellposedness of the problems, the design of accurate numerical algorithms, the performing of efficient computational simulations as well as the validation of the model by comparison to experimental results or clinical data

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IP5

Energetic Variational Approaches in Complex Fluids

In the spirit of the seminal works of Rayleigh and Onsager, we employ a general framework involving various energetic variational approaches, in particular, the least action principle (LAP) and the maximum dissipation principle (MDP), to study a wide class of different complex fluids. The framework focus on the couplings between different parts of the system that are the consequences of different physics from different scales. I will illustrate the approaches with polymeric fluids and ionic fluids. I will present our recent results as well as difficulties in modeling, numerical simulations and analysis related to the study of these materials.

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IP6

Rough Stochastic PDEs

There are several natural situations giving raise to stochastic PDEs with solutions that are so "rough" that their nonlinearity cannot be defined classically. However, in some typical cases, the situation is very close to "borderline". One classical example of such a "borderline" situation is the case of ordinary stochastic differential equations. There, the stochastic integral is "almost well-posed" in the sense that, if Brownian motion had sample paths that are α-Hölder continuous for some $\alpha > \frac{1}{2}$, one could use classical Riemann-Stieltjes integration and there would be little need for a stochastic calculus. Unfortunately, Brownian motion is only α-Hölder continuous for every $\alpha < \frac{1}{2}$... We will explore two examples of stochastic PDEs where a similar situation arises, but due this time to the lack of spatial regularity. In particular, we will provide a solution theory that still allows to make sense of solutions to these equations and to obtain sharp regularity result.

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IP7

***h*-principle and Fluid Dynamics**

There are nontrivial solutions of the incompressible Euler equations which are compactly supported in space and time. If they were to model the motion of a real fluid, we would see it suddenly start moving after staying at rest for a while, without any action by an external force. There are C^1 isometric embeddings of a fixed flat rectangle in arbitrarily small balls of the threedimensional space. You should therefore be able to put a fairly large piece of paper in a pocket of your jacket without folding it or crumpling it. I will discuss the corresponding mathematical theorems, point out some surprising relations and give evidences that, maybe, they are not merely a mathematical game.

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IP8

Landau Damping and Macroscopic Irreversibility for Plasmas and Galaxies

Landau damping is a fundamental collisionless stability phenomenon in plasma physics, as well as in galactic dynamics. Roughly speaking, it says that spatial waves are damped in time (very rapidly) by purely conservative mechanisms, on a time scale much lower than the effect of collisions. These evolution systems are described mathematically by the Vlasov-Poisson equations. These nonlinear partial differential equations are reversible in time; they describe the transport of particles through their mean-field interactions. We shall present a joint work with C. Villani which provides the first positive mathematical result for this damping effect in the nonlinear regime. We shall also discuss a general overview of this question and comment on its link with microscopic reversibility, macroscopic irreversibility and entropy.

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CP1

Convergence and Stability Analysis of the T-Method for Delayed Diffusion Mathematical Models

In this work a theta-method is proposed to treat mixed problems for reaction-diffusion equations. We give conditions so that our reaction-diffusion model is asymptotically stable. We study the numerical stability of our scheme via the spectral radius condition. We give necessary and sufficient conditions so that our scheme is asymptotically stable when theta is in [0, 1/2) while when theta is in [1/2,1] we give a condition to get asymptotic stability. We include several numerical examples to validate the effectiveness of the method.

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CP1

A Numerical Routine for Solving An Eigenvalue Problem on a Disk

When a vibrating structure is rotated, the vibrating pattern rotates at a rate proportional to the rate of rotation of the structure. This effect, observed by Bryan, is utilized in the vibratory gyroscopes that navigate space shuttles. Recently expressions were derived for calculating Bryan's factor in terms of eigenfunctions that had not yet been determined. In this paper we numerically determine these eigenfunctions for the first few circumferential numbers and numerical values for Bryan's factor.

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CP1

A Fast Mixed-Precision Strategy for Iterative Gpu-Based Solution of the Laplace Equation

Our work is concerned with the development of a generic high-performance library for scientific computing. The library is targeted for assembling flexible-order finite-difference solvers for PDEs. Our goal is to enable fast solution of large PDE systems, fully exploiting the massively parallel architecture of Graphics Processing Units. We will detail a strategy for an iterative mixed-precision p-multigrid solver of the Laplace equation, which appears as a computational bottleneck in applications in coastal and offshore engineering.

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CP1

A Finite Element Algorithm for Inverse Sturm-Liouville Problems Using Least Squares Formulation

Inverse problems arise in many areas of science and mathematics, including geophysics, astronomy, tomography and medical biology. Inverse Sturm-Liouville problems (SLP) is a branch of inverse problems that has applications in most of these areas, and our motivation for studying such problems comes from an application in biomechanics, particularly in estimating material parameters for soft tissues. We propose a constructive numerical algorithm based on finite element methods to recover the potential of a SLP using least squares formulation.

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CP1

Iterative Schemes for Bump Solutions in a Neural Field Model

We develop two iteration schemes for construction of localized stationary solutions (bumps) of a one-population Wilson-Cowan model with a smoothed Heaviside firing rate function. The first scheme is based on the fixed point formulation of the stationary Wilson-Cowan model. The second one is formulated in terms of the excitation width of a bump. Using the theory of monotone operators in ordered Banach spaces we justify convergence of both iteration schemes.

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CP2

NLSEmagic: A High-Order Multidimensional GPU-Accelerated Code Package for Simulating the Nonlinear Schrdinger Equation

We present a powerful, simple to use, package named NLSEmagic to integrate nonlinear Schrödinger equations in multiple dimensions. NLSEmagic relies on high-order compact finite-difference schemes implemented for graphic processing unit (GPU) parallel architectures. These freely distributable codes are many times faster than their serial counterparts, and are much cheaper than standard parallel clusters. With usability and portability in mind, the GPU-enabled C codes are implemented to directly interface with MATLAB.

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CP2

Implementing the Finite Volume Method on a Rectangular Collocated Grid

We formulate an algorithm to solve steady-state, laminar and incompressible fluid flow on a collocated rectangular grid. The chief aim is to considerably simplify existing FVM techniques such as the Semi Implicit Method for Pressure Linked Equations (Patankar, 1972), while simultaneously accounting for contributions of neighbouring cells pressure correction errors. Taking driven-cavity flow as an instance, the central differencing scheme, the divergence theorem and the TDMA two-pass solver are invoked to discretize the Navier-Stokes equations.

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CP2

Alternating Direction Implicit Finite Difference Method for the 3-D Wave Equation: P-SV Vectorial Case

Partial differential equations are the base of many physical models. Therefore it is essential to approximate their solution numerically. Following the pioneering ideas first presented in (Douglas & Peaceman, 1955) and (Peaceman & Rachford 1959) we develop a new second-order direction implicit (ADI) scheme, based on the idea of the operator splitting where 3-D problems are solved by a succession of 1-D tridiagonal systems. This new scheme for the 3-D wave equation is applied to model elastic wave propagation in heterogenous media for the P-SV vectorial case. The advantage of this approach over the traditional explicit schemes is that it is unconditionally stable and there is no limitation regarding the size of the time step.

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CP2

The von Karman Theory for Incompressible Elastic Shells

Starting from the 3d nonlinear elasticity,we rigorously derive the von Karman thin film theory for incompressible materials. In case of thin plates, the Euler-Lagrange equations of the limiting energy functional give the incompressible version of the classical von Karman equations, obtained formally in the limit of Poisson's ratio $\nu \to 1/2$. Our analysis applies as well to more general case of shells, i.e. thin films with midsurface of arbitrary geometry, as long as they satisfy the following approximation property: C^3 first order infinitesimal isometries are dense in the space of all $W^{2,2}$ infinitesimal isometries. The class of surfaces with this property includes: subsets of R^2, convex surfaces, developable surfaces and rotationally invariant surfaces. Our analysis relies on the modern methods of calculus of variations and analysis.

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CP2

Computational Analysis of Invisibility Cloaking Using Nurbs

The purpose of this research is to develop a Non-Uniform Rational B-Spline (NURBs) method to accurately measure and graphically represent actions of electromagnetic cloaking specifically defined by the parameters of the Helmholtz Equation. Using singular transformation optics, the shape representation is that of an electromagnetic wave in topological space. Additional applications include not only invisibility cloaks but other aspects of stealth technology.

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CP3

Convergence of a Particle Method and Global Weak Solutions for a Family of Evolutionary Pdes

We provide global existence and uniqueness results for a family of fluid transport equations by establishing convergence results for the particle method applied to these equations. The considered family of PDEs is a collection of strongly nonlinear equations which yield traveling wave solutions and can be used to model a variety of fluid dynamics. The equations are characterized by a bifurcation parameter b, which provides a balance for the nonlinear solution behavior, and a kernel $G(x)$, which determines the shape of the traveling wave and the length scale. For some special cases of b and $G(x)$, the equations are completely integrable and admit solutions that are nonlinear superpositions of traveling waves that have a discontinuity in the first derivative at their peaks and therefore are called peakons.
We apply a particle method to the considered evolutionary equations and provide a new self-contained method for proving its convergence. The latter is accomplished by using the concept of space-time bounded variation and the associated compactness properties. From this result, we

prove the existence of a unique global weak solution to the family of fluid transport equations for $b > 1$ and a particular choice of $G(x)$ and obtain stronger regularity properties of the solution than previously established.

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CP3

Research of Difference Schemes for Hyperbolic Heat Conduction Equation in Sobolev Space

A characteristic feature of hyperbolic heat conduction equation is that the coefficient of the highest time derivative is a small parameter. In the numerical solution of such problems, except stability and accuracy, the question of uniformity on the small parameter accuracy estimates is also fundamentally important. This paper is devoted to construction and justification of difference schemes for hyperbolic heat conduction equation in the Sobolev space. The stability and accuracy of these schemes are investigated. Uniform on small parameter of their accuracy estimates are generated. Two new a priori estimates are obtained for the three-layer operator - difference schemes. The theoretical findings are confirmed by computational experiment conducted on the basis of IDE Borland Turbo C + + Explorer for Windows.

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CP3

Boltzmann Equation with Specular Reflection in 2D Domains

We consider the initial-boundary value problem of Boltzmann equation with specular reflection boundary condition in 2 dimensional smooth convex domain and analytic nonconvex domain. In this talk the global existence and exponential decay in the L^∞ norm for cut-off hard potentials near an absolute Maxwellian are established.

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CP3

One Field Formulation and Simple Stable Explicit Schemes for Fluid Structure Interaction

We develop a one field formulation for the fluid structure (FS) interaction problem. It uses Arbitrary Lagrangian Eulerian (ALE) description for the fluid and Lagrangian description for the solid. We present a fully discrete explicit (in terms of how to determine the interface) scheme that uses conservative ALE description and allows any time step as long as it will not make the FS interface collides with itself or other fixed boundaries. Like in the continuous case, the stability bound is independent of the fluid mesh velocity. To prove the stability, we assume the flow is incompressible Navier-Stokes and the solid has convex strain energy (e.g. linear elastic). Perhaps unexpected, the proof will not work for Stokes flow and hence it shows the advantage of Navier-Stokes over Stokes in terms of stability. As the nonlinear convection term in the fluid part is treated semi-implicitly, in each time step, we only need to solve a linear system if the solid is linear elastic. Two numerical tests including the benchmark test of Navier-Stokes flow past a Saint Venant-Kirchhoff elastic bar are performed to show the power of this one field formulation.

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CP3

Variational Schemes in Nonlinear Elastodynamics, the Positivity of Determinants, Convergence and Relative Entropy Method

We study radial elastodynamics for isotropic elastic materials; these form a system of non-homogeneous conservation laws. We construct a variational scheme that decreases the total mechanical energy and also leads to physically realizable motions that avoid interpenetration of matter. In addition, with the aid of the relative entropy method, we establish convergence of time-continuous interpolates obtained via three-dimensional variational schemes (studied by S. Demoulini, D. Stuart, A. Tzavaras) to a smooth solution of the elastodynamics.

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CP4

An Algebraic Procedure to Construct Exact Solutions of Nonlinear Evolution Equations

In this paper, we implemented the functional variable method for the exact solutions of the Zakharov Kuznetsov-Modified Equal-Width, the modified Benjamin-Bona-Mahony and the modified KdV-Kadomtsev-Petviashvili equations. By using this scheme, we found some exact solutions of the above-mentioned equations. The obtained solutions include solitary wave solutions, periodic wave solutions and combined formal solutions. The functional variable method presents a wider applicability for handling nonlinear wave equations.

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CP4

Application of Hes Variational Approach Method

for Single Degree of Freedom Problems in Nonlinear Vibration

This paper, Hes Variational Approach Method is used to obtain the exact solution of nonlinear problems in nonlinear vibration. The governing equation is obtained by using Lagrange method and it is solved analytically by Hes Variational Approach Method.In the VAM, just one iteration takes one to high exactness of the solutions, counter to the different methods. Some patterns are given to demonstrate the impressiveness and serviceableness of the method

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CP4
An Approximate Solution for a Fractional Advection Diffusion Equation

Recently, many transport problems, involving diffusion, have been formulated on fractional differential equations where the fractional derivatives are used to model the anomalous diffusion phenomenon. A one dimensional fractional advection diffusion model is considered, where the usual second-order derivative gives place to a fractional operator. To compute the approximate solution, we propose an explicit difference method which is second order accurate. Consistency and stability of the method are examined and numerical tests are presented.

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CP4
Linear Quadratic Mean Field Games

The theory of Mean Field Games has grown rapidly after the pioneering paper by Lasry and Lions (2007). For the recent development and its applications, one can refer to, for example, the survey (Gueant et al. 2011) and the references therein. In this talk, I shall introduce a class of Mean Field Games in which both the pay-off function and cost functional are quadratic in state variable, control variable together with the mean field term; besides, the controlled dynamics is linear and also consists of a mean field term. We shall also briefly discuss about the existence and uniqueness of both the value function and the optimal control of each of these Mean Field Games; indeed, we can establish them by using a method that combines adjoint equation approach and the theory of backward stochastic differential equations.

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CP5
Linear elasticity as Gamma-limit of finite elasticity under weak coerciveness conditions

The energy functional of linear elasticity is obtained as Γ-limit of suitable rescalings of the energies of finite elasticity. The quadratic control from below of the energy density $W(\nabla v)$ for large values of the deformation gradient ∇v is replaced here by the weaker condition $W(\nabla v) \geq |\nabla v|^p$, for some $p > 1$. Energies of this type are commonly used in the study of a large class of compressible rubber-like materials.

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CP5
Pseudo-Differential Operator Involving Fractional Fourier Transform

Pseudo-differential operator involving fractional Fourier transform associated with symbol $a(x, y)$ is defined. An integral representation of pseudo-differential operator and a Sobolev space boundedness result is obtained

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CP5
Modern Traffic Flow Models

I will talk about several models of vehicular traffiŒc. I will fiørst describe microscopic cellular automata models and show how the vehicle interaction can be modeled through the look-ahead interaction potential, which leads to slow down due to heavy traffiŒc conditions. I will then proceed with the derivation of the semi-discrete mesoscopic and continuous PDE-based macroscopic models. The resulting (systems of) PDEs are hyperbolic (systems of) PDEs with global flÆuxes, which make it very challenging from both analytical and numerical perspectives. The last part of my talk will be devoted to numerical methods for hyperbolic systems with global Æfluxes.

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CP5
An Isoperimetric Problem With Long-Range Inter-

actions on the Two-Sphere

There is currently much interest on the mathematical analysis of phase separation of block copolymers and their sharp interface limit leading to a nonlocal isoperimetric problem (NLIP). In this talk I will analyze the NLIP on the two-sphere and characterize the global minimizer when the parameter controlling the influence of the nonlocality is small. Furthermore, I will demonstrate stability/instability results of certain critical points depending on where in the parameter regime one looks.

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CP5
Semigroup Approach to Nonlinear Flow-Structure Interactions

We consider a subsonic flow-structure interaction between a perturbed wave equation and a second order nonlinear plate with a rotational parameter. A suitable inner product on the finite-energy space allows the application of monotone operator theory which leads to weak and strong well-posedness for several classes of nonlinear dynamics. We show that well-posedness is preserved with nonlinear boundary damping, and discuss asymptotic properties of the corresponding nonlinear semigroups as the rotational term degenerates.

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CP6
Construction of Dynamic Co-Seismic Sea Bed Displacements for Tsunami Generation Problems

We study tsunami wave generation and we present a new method for the construction of dynamic co-seismic sea bed displacements. This method relies on the finite fault solution (see slip distribution) and dynamic sea bed deformation scenarios (see rupture dynamics). The bottom motion is reconstructed and waves induced on the oceans free surface are studied. The 2006 Java tsunami generation case is computed with three different models. A comparison between them gives good agreement.

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CP6
Time Decay for the Solutions of a Coupled Nonlinear Schrdinger Equations

Using Morawetz Radial Identity, we show that the local solutions of a coupled nonlinear Schrodinger equations decay in time.

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CP6
Turbulent Flame Speeds for G-Equations

Joint work with Jack Xin and Yifeng Yu. In combustion theory various models have been proposed in modeling of the flame propagation. By level curve formulation, G-equation describes the motion of the flame front by a constant normal velocity (called laminar flame speed) and the advection of the fluid. If the initial flame is planar in some direction, the front will be wrinkled by the advection and becomes very complicated in time. Eventually the front will evolve into an asymptotic state propagating at a constant speed (called turbulent flame speed.) Consider the G-equation with 2D cellular flow. We are interested in the turbulent flame speed parameterized by the intensity of the cellular flow. For the basic G-equation model, the turbulent flame speed is enhanced by the cellular flow with marginally linear growth rate. If a dissipation term is added into G-equation, however, the growth rate will be drastically altered and become uniformly bounded. Correction terms may be also added to laminar flame speed to take account of the effects of the curvature of the level curve and the strain of the advection. We will discuss numerical methods in computing the turbulent flame speed. The numerical results support the laboratory observation that flame front may be quenched by the turbulence.

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CP6
Well-Posedness for Some Kinetic Models of Collective Behavior

The aim of this work is to give a well-posedness theory for general models of collective behavior of large groups of individuals which include a variety of effects: interaction through a potential, velocity-averaging, self-propulsion effects... We develop our theory in a space of measures, using mass transportation distances, and as consequence of it we show also the convergence of particle systems to their corresponding kinetic equations.

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CP6

Bounds on the Growth of High Sobolev Norms of Solutions to Nonlinear Schrödinger Equations

In this talk, we study the growth of Sobolev norms of solutions to Nonlinear Schrodinger Equations which we cant bound from above by energy conservation. The growth of such norms gives a quantitative estimate of the low-to-high frequency cascade. We present a frequency decomposition method which allows us to obtain polynomial bounds in the case of the 1D Hartree equation with sufficiently regular convolution potential, and which allows us to bound the growth of fractional Sobolev norms of the Cubic NLS on the real line. We will also present some 2D and 3D results.

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CP7

On the Convergence of Statistical Solutions of the 3D Navier-Stokes-α Model as $\alpha \to 0$

In this talk we consider statistical solutions of the 3D Navier-Stokes-α model with periodic boundary condition. We prove that under certain conditions statistical solutions of the 3D Navier-Stokes-α model converge to statistical solutions of the exact 3D Navier-Stokes equations as $\alpha \to 0$. The statistical solutions that we consider here arise from measures in suitable trajectory spaces, in a sense akin to that considered by Vishik and Fursikov.

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CP7

Incompressible Boussinesq Equations and Spaces of Borderline Besov Type

We prove local-in-time existence and uniqueness of an inviscid Boussinesq-type system. We assume the density equation contains nonzero diffusion and that our initial vorticity and density belong to a space of borderline Besov type.

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CP7

Inertial Waves in a Rapidly Rotating Cylinder

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

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CP7

Some Results on Statistical Solutions of the Navier-Stokes Equations for an Extended Class of External Forces

The study of statistical solutions of the Navier-Stokes equations has been considered mostly for forcing terms with values in the phase space H of square-integrable, divergence-free vector fields with the appropriate boundary conditions. In this talk, we discuss the existence of statistical solutions for forcing terms which are square-integrable in time and with values in the natural dual space V', where V is the subspace of H of functions with square-integrable derivative, with the corresponding boundary conditions. First, we prove the existence of statistical solutions which satisfy the so-called strengthened mean energy inequality. Then, we also show that for certain classes of forcing terms with values in V', any statistical solution must satisfy this strengthened mean energy inequality. This last result is based on the extension to more general forces of a result of equivalence between the energy inequality and the strengthened energy inequality for individual weak solutions.

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CP8

Formation of High-Temp/low-Viscosity Fingers Within Lava Flow

As lava viscosity can change 1-2 orders of magnitude due to small changes in temperature, several studies have predicted the formation of low-viscosity/high-speed fingers (similar to a Saffman-Taylor type instability). We examine the onset and evolution of such fingers within a Hele-shaw-type flow. In particular, we attempt to identify steady-state laminar solutions that would provide pahoehoe lava flows with a natural mechanism for the formation of lava channels/tubes within an initially uniform sheet flow.

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CP8

Shape Selection in Hyperbolic Non-Euclidean Plates

Non-Euclidean plates are thin elastic sheets in which the preferred intrinsic geometry of the mid-surface corresponds to a surface with nonzero Gaussian curvature. These sheets model the complex geometries generated by the differential growth of soft tissue such as the rippling in leaves and sea slugs. We present a study of free non-Euclidean discs with a constant negative Gaussian curvature curvature. The equilibrium configuration taken by these sheets are solutions to a Föppl Von-Kàrmàn type coupled system of equations in which configurations free of any in plane stretching correspond to isometric immersions of the hyperbolic plane.

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CP8

Global Solutions to Bubble Growth in Porous Media

A model of an injected fluid into another viscous fluid leads to a moving boundary problem. We present solutions to the free boundary problem in terms of time-derivative of generalized Newtonian potentials, and show that the bubble occupies the entire space as the time tends to infinity if and only if the internal potential of the initial bubble is a quadratic polynomial. This classification relies on the quadratic growth of solutions to certain free boundary problems.

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CP8

Evolution of Elastic Thin Films with Curvature Regularization Via Minimizing Movements

We consider the evolution equation with curvature regularization that models the motion of a two-dimensional elastic thin film on a rigid substrate. The mismatch between the material lattices forces the film to be strained. We prove short time existence, uniqueness and regularity of the solution, using De Giorgi's minimizing movements to exploit the L^2-gradient flow structure of the equation. This seems to be the first analytical result in the case of elasticity without surface diffusion.

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CP9

Power-Law Asymptotics and Growth of Heterogeneous Sandpiles

I will discuss joint work with M. Mihailescu, J.D. Rossi, and M. Perez-Llanos on the asymptotic behavior, via Mosco convergence, of a class of power-law functionals with variable exponents, and present some applications to the study of a heterogeneous model of sandpile growth.

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CP9

Domain and Trajectory Bundles for Fluid Structure Interaction

We present a new methodology for the study and analysis of the solvability of fluid structure interaction problems. We introduce definitions of domain bundles and trajectory bundles which are instances of Banach bundles that may be used for establishing the existence of strong and classical solutions for fluid structure interaction problems. Rather than the more common method of lifting the interaction problem to a fixed reference domain, we develop the existence theory in a modular fashion and show how classical existence results can be adapted to these vector bundles and then coupled to iterative mappings for the structural displacements in order to establish the existence of fixed points which solve the fluid-structure interaction problems by construction. We demonstrate these techniques on a variety of different example problems, including the self-propelling problem for a shape changing body in three spatial dimensions.

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CP9

Borehole Heat Exchanger Modeling Validation

We present the development and validation of a numerical model for the simulation of energy flows and temperature changes in and around a borehole heat exchanger when a fluid circulates through a U-tube. The FlexPDE software is used to solve the model of a heat exchanger. The validated model (through comparisons with experiments) is used to study how various parameters (ground thermal conductivity etc.) affect the temperature of the inlet and outlet fluid.

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CP9

The 2D Selective Withdrawal Transition: Analogies with Microelectromechanical Systems

Free boundaries in selective withdrawal systems have been observed undergoing topological transitions through apparently-singular steady states as the withdrawal rate is increased. We transfer the study of this transition to a simpler class of problems that are analogous to those found in the study of MEMS. By first considering a restricted family of one dimensional boundaries related to two-parameter conformal maps, we aim to identify the mechanisms that control the boundary breakdown in two dimensions.

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CP9

Incompatibility and Hysteresis in Shape Memory Alloys

For certain martensitic phase transformations, one observes a close relation between the width of the thermal hysteresis and the compatibility of two phases. The latter is in the context of geometrically non-linear elasticity measured by the deviation of the middle eigenvalue of the transformation stretch matrix from one. This observation forms the basis of a theory of hysteresis that assigns an important role to the energy of the transition layer (Zhang, James, Müller, Acta mat. 57(15), 4332–4352, 2009). Following this ansatz, we study the energy barriers leading to hysteresis, and analyze the shapes of energetically optimal transition layers for low hysteresis alloys.

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CP10

Global Stability for the N-Species Lotka-Volterra Tree Systems of Reaction-Diffusion Equations

We consider system of reaction-diffusion equations

$$(u_i)_t - D\Delta u_i = u_i \left(b_i - \sum_{j=1}^{n} a_{ij} u_j \right), \quad 1 \leq i \leq n, \quad (1)$$

where $u_i = u_i(t,x), (t,x) \in [0,\infty) \times R_+^m$, $D = \mathrm{diag}(D_1, ..., D_n), D_i > 0$. For case of graph $G((a_{ij})_{n\times n})$ being a tree, applying invariant region method and with the aid of Volterra multiplier we obtain a set of sufficient conditions for the globally asymptotic stability for Cauchy problem of the system. The criteria are in explicit forms of the parameters, and are easily verifiable to competition model, cooperation model, as well as to predator-prey model.

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CP10

A New Electrical Model of Cardiac Cells

Action potential propagation in cardiac tissue has been classically understood to occur through gap junctions. However, recent experimental studies have shown that ephaptic coupling, or field effects, may be another method of communication between cardiac cells. Here we present and discuss results from a new model for the electrical activity in cardiac cells with simplifications that afford more efficient numerical simulation, yet captures complex cellular geometry and spatial inhomogeneities that are critical to ephaptic coupling.

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CP10

Local Existence and Finite Time Blowup in a Class of Stochastic Nonlinear Wave Equations

We consider a stochastic version of the nonlinear wave equation considered by Messaoudi and Said-Houari, that models the longitudinal motion in a viscoelastic configuration, obeying a nonlinear Voight model. For the deterministic equation a global non existence theorem has been proved earlier, under the assumption that the initial data is sufficiently negative. We first show local existence for the stochastic equation, when the power on the source term is smaller than that on the damping term. We next derive conditions under which the equation blows up in finite time, when the power on the source term is larger than that on the damping term. We are in fact able to show that there is possibly a region of positive initial data for which the blow up is possible.

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CP10

Analysis of a Mathematical Model ForErythropoiesis

We consider a mathematical model for the regulation of erythropoiesis , the process where new blood cells are created from precursor cells in the bone marrow at a rate proportional to the amount of the hormone erythropoietin present in the body. These cells age over a period of months through abrasion in the capillaries, eventually losing all ability to transport oxygen, at which point they are destroyed by phage cells. Mature red blood cells carry hemoglobin the concentration of which is fairly constant among the population of red blood cells and therefore a good measure of red blood cells levels. Erythropoietin and hemoglobin are involved in a negative feedback loop.We analyze the system of partial differential equations describing the mathematical model and reduce it to a pair of threshold-type delay differential equations to perform a stability analysis. We perform a complete parameter study and several numerical tests.

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CP10

Stretch-Dependent Proliferation in a One-Dimensional Elastic Continuum

Model of Cell Layer Migration

A recently developed mathematical model of cell layer migration based on an assumption of elastic deformation of the cell layer leads to a generalized Stefan problem. The model is extended to incorporate stretch-dependent proliferation, and the resulting PDE system is analyzed for self-similar solutions. The efficiency and accuracy of adaptive finite difference and MOL schemes for numerical solution are compared. We find a large class of assumptions about the dependence of proliferation on stretch that lead to traveling wave solutions.

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CP11

To the Construction of Greens Functions of Terminal-Boundary-Value Problems for the Black-Scholes Equation

A number of Greens functions has earlier been constructed for a variety of problems posed for the Black-Scholes equation that finds numerous applications. An approach that appears efficient for such construction is based on a combination of the integral Laplace transform with the method of variation of parameters. Further analysis shows that the number of problem settings, for which the approach could be productive, can be extended. One of such extensions is analyzed in detail.

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CP11

Bifurcation Analysis for the Lugiato-Lefever Equation in Two Space Dimensions

We consider a nonlinear Schrödinger equation with cubic nonlinearity, damping, detuning and external force in two space dimensions. It is a model equation for pattern formation in nonlinear optics. Because of the damping term, it defines a weak dissipative system. We study the steady-state bifurcation of spatially homogeneous equilibrium point for the equation on square and hexagonal lattices within the space of periodic functions with respect to the lattice.

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CP11

Effect of Non-Newtonian Pulsatile Flow on Convective Diffusion in Annulus

This paper presents an exact analysis of the dispersion of a solute in Casson fluid flow through an annulus between two coaxial cylinders under the influence of periodic pressure gradient. Using the generalized dispersion model which is valid for all time after the injection of a solute, the entire process is expressed in terms of two dispersion coefficients i.e. convection and diffusion coefficients. This model analyses how the spreading of tracer is influenced by the non-Newtonian nature and periodic pulsation of the fluid. The results of the study are of great importance in understanding the dispersion process in cardiovascular flows in particular in catheterized arteries.

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CP11

Periodic Unfolding and Oscillating Test Functions for the Homogenization in a Periodically Perforated Domain

We study the homogenization of the Laplace equation with nonhomogeneous Robin boundary conditions in a periodically perforated domain. First we prove the main convergence results using the method of oscillating test functions of Tartar, then we treat the same problem by applying the periodic unfolding method. We show that the auxiliary functions introduced in the first method are not needed in the second one for proving the homogenization results.

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CP14

Blow-Up and Global Existence for a General Class of Nonlocal Nonlinear Coupled Wave Equations

We study the initial-value problem for a general class of nonlinear nonlocal coupled wave equations:

$$\begin{aligned} &u_{1tt} = (\beta_1 * (u_1 + g_1(u_1, u_2)))_{xx}, \qquad x \in R, \quad t > 0 \\ &u_{2tt} = (\beta_2 * (u_2 + g_2(u_1, u_2)))_{xx}, \qquad x \in R, \quad t > 0 \\ &u_1(x, 0) = \varphi_1(x), \quad u_{1t}(x, 0) = \psi_1(x) \\ &u_2(x, 0) = \varphi_2(x), \quad u_{2t}(x, 0) = \psi_2(x). \end{aligned}$$

The problem involves convolution operators with kernel functions whose Fourier transforms are nonnegative. Some well-known examples of nonlinear wave equations, such as coupled Boussinesq-type equations arising in elasticity and in quasi-continuum approximation of dense lattices, follow from the present model for suitable choices of the kernel functions. We establish local existence and sufficient conditions for finite time blow-up and as well as global existence of solutions of the problem.

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CP14

The Cauchy Problem for a Two-Dimensional Nonlocal Nonlinear Wave Equation

We study the Cauchy problem of a general class of two-dimensional nonlinear nonlocal wave equations:

$$w_{tt} = \left(\beta * \frac{\partial F}{\partial w_x}\right)_x + \left(\beta * \frac{\partial F}{\partial w_y}\right)_y, \quad (x,y) \in R^2, \quad t > 0$$
$$w(x,y,0) = \varphi(x,y), \quad w_t(x,y,0) = \psi(x,y).$$

The above partial differential equation governs anti-plane shear motions in nonlocal elasticity. The nonlocal nature of the problem is reflected by a convolution integral in the space variables. The Fourier transform of the convolution kernel is nonnegative and satisfies a certain growth condition at infinity. For initial data in L^2 Sobolev spaces, conditions for global existence or finite time blow-up of the solutions of the Cauchy problem are established.

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CP14

Uniform Boundary Stabilization of a Wave Equation with Nonlinear Acoustic Boundary Conditions and Nonlinear Boundary Damping

We consider a wave equation with nonlinear acoustic boundary conditions. This is a coupled system of hyperbolic equations modeling an acoustic/structure interaction, where the coupling is ¡i¿nonlinear¡/i¿ rather than linear. Using the methods of Lasiecka and Tataru, we demonstrate well-posedness and uniform decay rates for finite energy solutions. Special attention is given to the relationship between (i) the mass of the structure, (ii) the nonlinear coupling term, and (iii) the size of the nonlinear damping.

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CP14

Weak Solutions for a Class of Semilinear Elliptic Bvps in Unbounded Domains

In this study, we prove the existence of a weak solution for degenerate semilinear elliptic Dirichlet boundary-value problem

$$\begin{aligned} Lu(x) + \alpha \sum_{i=1}^{n} g_i(x) h_i(u(x)) D_i u(x) &= f(x) \quad \text{in } \Omega, \\ u(x) &= 0 \quad \text{on } \partial\Omega, \end{aligned}$$

in a suitable weighted Sobolev space, where $\Omega \subset \mathbf{R}^n$, $1 \le n \le 3$, is not necessarily bounded.

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MS1

A Lower Bound on Blowup Rates for the 3D Incompressible Euler Equation and a Single Exponential Beale-Kato-Majda Estimate

We prove a Beale-Kato-Majda criterion for the loss of regularity for solutions of the incompressible Euler equations in $H^s(R^3)$, for $s > \frac{5}{2}$. Instead of double exponential estimates of Beale-Kato-Majda type, we obtain a single exponential bound on $\|u(t)\|_{H^s}$ involving a length parameter previously introduced by P. Constantin. In particular, we derive lower bounds on the blowup rate of such solutions.

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MS1

Global Solutions of the Landau-Lifshitz equation

The Landau-Lifshitz equation (which includes as a special case the Schroedinger map equation) is a nonlinear Schroedinger-type equation of geometric and physical origin (ferromagnetism). I will describe some results on global regularity and asymptotic behaviour in the energy-critical 2D setting, from joint work with Eva Koo, and with Kenji Nakanishi and Tai-Peng Tsai.

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MS1

The Dynamics of Perturbations of Minimal Mass Solitons

We study soliton solutions to several nonlinear dispersive equations with saturated nonlinearities. We consider a small perturbation of a minimal mass soliton and identify a system of ODEs extending the work of Comech and Pelinovsky and of Comech Cuccagna and Pelinovsky, which model the behavior of the perturbation for short times. For the nonlinear Schrodinger equation (NLS), we provide numerical evidence that under this system of ODEs there are two possible dynamical outcomes, in accord with the conclusions of Pelinovsky, Afanasjev and Kivshar. Generically, initial data which supports a soliton structure appears to oscillate, with oscillations centered on a stable soliton. For initial data which is expected to disperse, the finite dimensional dynamics initially follow the unstable portion of the soliton curve. For the generalized Korteweg-deVries equation with saturated nonlinearity, we provide initial evidence that the dynamics of a small perturbation of the minimal mass soliton are governed by a simple two-dimensional system of ODEs. Analysis of the phase plane indicates that the solution either disperses or eventually approaches a nearby stable soliton, without oscillation.

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MS1

On the Global Well-posedness of the Euler Equation Forced by a Riesz Transform

I will address the issue of global well-posedness of smooth solutions u of a dispersively forced Euler equation, in the two dimensional case. That is, the forcing equals to Ru, where R is a singular integral operator.

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MS1

Well-posedness Issues for Degenerate Dispersive Equations

Linear dispersion plays a fundamental role in the study of a large number of physical scenarios and has been the subject of intense theoretical development in recent years. Consequently there has been an explosion of results concerning nonlinear dispersive equations. Nevertheless there are situations in which the mechanism which creates dispersion is itself nonlinear and degenerate. Examples can be found in the study of sedimentation, magma dynamics, granular media, numerical analysis and elasticity. Little is understood about general well-posedness issues for such equations. In this talk we will discuss some recent results which show that degenerate dispersive effects can result in catastrophic instability akin to a backwards heat equation.

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MS2

Vortices for a Two-component Ginzburg-Landau Model

We study vortices in a Ginzburg-Landau model for a pair of complex-valued order parameters. Multi-component functionals have been introduced in the context of unconventional p-wave superconductors and spinor Bose-Einstein condensates to include spin coupling effects. As in the classical Ginzburg-Landau model, minimizers will exhibit quantized vortices in response to boundary conditions or applied fields. However, we show that the interaction between the two components allows for vortices with a more exotic core structure. Our results are based on a combination of variational and PDE methods, blowing up around the vortex core and studying the resulting system and its local minimizers.

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MS2

A Zigzag Pattern in Micromagnetics

We study a simplified model for the micromagnetic energy functional in a specific asymptotic regime. The analysis includes a construction of domain walls with an internal zigzag pattern and a lower bound for the energy of a domain wall. Under certain conditions, the two results combined match into a Gamma-convergence result. This is a joint work with Roger Moser (University of Bath, UK).

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MS2

On Some Variational Problems Related to Fractional Phase Transitions

In this talk I will present some variational problems involving energies of "fractional order" and related to phase transitions. I will specially focus on fractional isoperimetric inequalities and their quantitative versions. This is a joint work with N. Fusco and M. Morini.

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MS2

Energy Estimates and Cavity Interaction for a Simple Cavitation Model

In joint work with Duvan Henao we study a toy model for cavitation with critical power. Using ball-construction methods, we provide energy lower bounds in terms of the shapes and locations of the cavities, and energy upper bounds via constructions.

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MS2

Vortex Liquids and the GInzburg-Landau Equations

I will discuss vortex dynamics for the time-dependent Ginzburg-Landau equations with asymptotically large numbers of vortices. For dilute vortex liquids it is shown that sequences of solutions converge to the hydrodynamic limit.

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MS3

Incompressible Limit of the Compressible Hydrodynamic Flow of Liquid Crystals

This talk is concerned with the incompressible limit of the compressible hydrodynamic flow of liquid crystals with periodic boundary conditions in $R^N (N = 2, 3)$. The derivation of the compressible model is given by least action principle and variations. The uniform (in λ (Mach Number)) local existence of strong solutions to the compressible is obtained. The limit behavior including the convergence rate from the compressible model to the incompressible model is proved. Therefore, the global existence of strong solutions to the incompressible model under small conditions is also given.

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MS3

Multiscale Coupling for Liquid Crystals

Abstract: In this talk, we will focus on the multiscale-multiphysics coupling in the modeling of liquid crystal flows. The focus will be on the relation between different kinematic rules and the induced macroscopic elastic stresses. We will also discuss the roles of Eleslie conditions and the Parodi's condition in the dynamical properties of the flow system.

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MS3

Passage from Mean-field to the Continuum Landau-de Gennes Theory for Nematic Liquid Crystals

We propose a new continuum energy functional for nematic liquid crystals derived from mean-field principles. It is well-known that the continuum Landau-de Gennes predictions fail to be physically realistic in the low-temperature regime. Of key importance in our analysis is the definition of a new bulk potential that *blows-up* or diverges whenever the macroscopic **Q**-tensor order parameter takes values outside the *physical domain* predicted by mean-field theory. The proposed model can account for uniaxiality, biaxiality and spatial inhomogeneities in a three-dimensional context. For spatially inhomogeneous systems, we prove that the Landau-de Gennes theory is ill-posed in the presence of a cubic term in the elastic energy density and we make important mathematical distinctions between the isotropic *one-constant* elastic energy density and more general quadratic elastic energy densities.

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MS3

An Analysis of the Effect of Artificial Stress Diffusivity on the Flow Dynamics of Creeping Viscoelastic Flow

The effect of stress diffusivity is examined in both the Oldroyd-B and FENE-P models of a viscoelastic fluid in the low Reynolds (Stokes) limit for a 2D periodic time-dependent flow. A local analytic solution can be obtained when assuming a viscometric flow of the form $\mathbf{u} = Wi^{-\mathbf{1}}(\mathbf{x}, -\mathbf{y})$, where Wi is the Weissenberg number. In this case the width of the birefringent strand of the polymer stress scales with the added viscosity as $\nu^{1/2}$, and is independent of the Weissenberg number. Also, the maximum extension of the polymer coils remains finite with any stress diffusion and scales as $Wi \cdot \nu^{-1/2}$. These predictions closely match the full simulations. When a FENE-P penalization term is included the percent of extension can be predicted based on Wi, ν, and b, the maximum extensibility parameter.

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MS3

Models for Active Liquid Crystal Materials and Their Application to Biomaterials Modeling

Active liquid crystals are liquid crystalline materials whose large molecules are mobile. Flows of active liquid crystals have been observed in mesoscopic biological systems like cytoskeletal regions of a live cell. Various efforts have been made to derive suitable hydrodynamic theories for the intriguing flowing materials. In this talk, I will give an overview of the latest developement in modeling and simulation of active liquid crystal materials. I will discuss the application of the models in studying cell motility and oscillation.

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MS4

Shock Diffraction Problems in Multidimensional Hyperbolic Conservation Laws

We will discuss some recent efforts in the rigorous mathematical analysis of shock diffraction problems for multidimensional hyperbolic conservation laws. We will focus mainly on the shock diffraction by two-dimensional convex corned wedges in compressible fluid flow determined by the nonlinear wave system. This shock diffraction problem can be formulated as a boundary value problem for second-order nonlinear partial differential equations of mixed elliptic-hyperbolic type in an unbounded domain. It can be further reformulated as a free boundary problem for nonlinear degenerate elliptic equations of second order. We will present a global theory of existence and regularity for this shock diffraction problem, as well as several new mathematical ideas/techniques motivated by the earlier work by Feldman and myself. Further results, perspectives, and open problems on this topic will be also addressed.

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MS4
Existence of Algebraic Vortex Spirals

Abstract not available at time of publication.

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MS4
Conservation Laws with Distributed Control

We consider a balance law in one space variable $u_t + [f(u)]x = z(t,x)$, with f strictly convex. We regard the source term z as a bounded control, and characterize the set of attainable profiles $u(T,\cdot)$ at a fixed time T in two cases

1. whenever z is defined on a strip $[0,T]\times$;
2. whenever $z(t,\cdot)$ is compactly supported in an interval $[a,b]$, independent on $t \in [0,T]$.

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MS4
Conservation Laws on Networks

Abstract not available at time of publication.

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MS5
Phase Transition in a System of Self-propelled Particles

Abstract not available at time of publication.

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MS5
On Repulsion in Biological Aggregation Equations

Abstract not available at time of publication.

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MS5
Mathematical Modeling of Collective Displacements: From Microscopic to Macroscopic Description

Abstract not available at time of publication.

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MS5
A New Model for Self-organized Dynamics and its Flocking Behavior

Self-organized dynamics is driven by 'rules of engagement', which describe how each agent interacts with its 'neighbors'. They consist of long-term attraction, mid-range alignment and short-range repulsion. Many self-propelled models are driven by the balance between these three forces, which yield emerging structures of interest. Here, we introduce a new particle-based model driven by self-alignment, which addresses several drawbacks of existing models for self-organized dynamics. We will explain the emerging behavior of flocking in our proposed model, when the non-symmetric pairwise interactions between its agents decays sufficiently slow. The methodology presented here is based on the new notion of active sets, which carries over from particle to kinetic and hydrodynamic descriptions.

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MS6
Effective Dielectric Boundary Forces in Variational Implicit Solvation

The competition of electrostatic and entropic interactions influences crucially biomolecular conformations. In the variational implicit-solvent modeling (VISM), the dielectric boundary force is the key in the description of electrostatic interactions. Such forces are defined and their analytic formulas are derived based on the Coulomb-field, Yukawa-field, and Poisson-Boltzmann approximations of electrostatic free energies. The notion of shape derivatives is employed. The implementation of the resulting theory in the context of the level-set VISM is discussed.

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MS6
New Poisson-Boltzmann Type Equations

Continuing our previous work for ionic solutions with two ion species of opposite charges [Nonlinearity, 24 (2011) 431–458], we study a new Poisson-Boltzmann type (PB_n) equation which describes the equilibrium of electrolytes with multiple types of ionic species. Under Robin type boundary conditions with various material coefficients, we give the rigorous proof of the asymptotic behavior of the solutions of PB n equations in one spatial dimensional

cases, as the parameter approaches zero. When the global electro-neutrality holds, we find different asypmtotic behaviors between PB_n and the standard Poisson-Boltzmann (PB) equations. For finite size effects, we may introduce another PB equation having same asymptotic behavior as Andelmann's results (1997).

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MS6
Fast Solvers for Nonlocal Continuum Electrostatic Models

The nonlocal continuum electrostatic model is an important extension of the classical Poisson dielectric model, but very costly to be solved in general. In this talk, we introduce one commonly-used nonlocal continuum dielectric model of water and a modified nonlocal model for protein in water. We then show that both models can be transformed equivalently from their original integro-differential equations into systems of partial differential equations. In this way, the complexity of the nonlocal model is simplified sharply. We also describe our finite element program package for solving the nonlocal model, and report the analytical solutions of three nonlocal ionic Born models that we obtained recently. Moreover, we demonstrate that a nonlocal continuum electrostatic model is a much better predictor of the solvation free energy of ions than the classic Poisson dielectric model. This project is a joined work with Prof. L. Ridgway Scott at the University of Chicago. It is supported in part by NSF grant #DMS-0921004.

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MS6
Efficient Algorithms for Biomolecular Electrostatics with Dielectric Discontinuities

In this talk, we will discuss some recent results on efficient electrostatic algorithms of surface polarization charges in the presence of dielectric discontinuities, in both salt-free and ionic solvents, including the method of images and the generalized Born method. These algorithms are useful in molecular simulations of biological and soft matter systems when the polarization effects play a role. We will report the applications of these algorithms into two nano-scale systems. The first one is the spherical colloidal system. We will present our insight on electric double layer with Monte Carlo simulations by systematically investigating the effects of image charges, ionic sizes, and discrete surface charges. The second system is an ion channel model. We have developed a new generalized Born algorithm to account for the polarization effect of membrane bilayer, which is incorporated in Monte Carlo program to provide an efficient tool for the study of ion transport in nanoscale channels.

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MS7
Harmonic Characterization of Balls in Stratified Lie Groups.

We extend, to the sub-Laplacians setting, a theorem by Aharonov, Schiffer and Zalcman regarding an inverse property for harmonic functions. As a byproduct, a harmonic characterization of the gauge balls is proved, thus extending a Kuran's theorem related to the Euclidean balls.

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MS7
Regularity Properties of Sets with Quasiminimal Surfaces in the Metric Setting

Abstract not available at time of publication.

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MS7
Title Not Available at Time of Publication

Abstract not available at time of publication.

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MS7
On the Distributional Divergence of Vector Fields Vanishing at Infinity

In this talk we present results concerning the solvability of the equation $div\ \mathbf{v} = F$ in various spaces of functions for the vector field $\mathbf{v}$. We find necessary and sufficient conditions on the right hand side F that guarantees the existence of solutions $\mathbf{v}$. We show that the equation $div\ \mathbf{v} = F$ has a solution $\mathbf{v}$ in the space of continuous vector fields vanishing at infinity if and only if F belongs to a closed subspace of the dual of $BV_{\frac{m}{m-1}}(\mathbf{R^m})$ (where the latter is the space of functions in $L^{\frac{m}{m-1}}(\mathbf{R^m})$ whose distributional gradient is a vector valued measure). In particular we show that, even though $div\ (\nabla u) = \Delta u = f \in L^m$ need not have a solution $u \in C^1$, to each $f \in L^m(\mathbf{R^m})$ there corresponds a continuous vector field $\mathbf{v}$ vanishing at infinity such that $div\ \mathbf{v} = f$.

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MS7

The Area and Co-area Formulas for Newtonian Functions Defined on Metric Spaces

Abstract not available at time of publication.

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MS8

The Invariant Measure of the Stochastic Navier-Stokes Equation

The mathematical proof of Kolmogorovs (1962) statistical theory of turbulence consists of proving the existence of the invariant measure of the Navier-Stokes equation, on which the statistical theory is based. In this talk we discuss how the laminar solution of the Navier-Stokes equation becomes unstable for large Reynolds number and the stable solution is the solution of the stochastic Navier-Stokes equation. This is the unique solution that describes fully-developed turbulence. In order to compare with experiments and simulations, we solve the stochastic Hopfs equation for the invariant measure. The Feynmann-Kac formula produces log-Poisson processes from the stochastic Navier-Stokes equation. These processes, first found by She, Leveque, Waymire and Dubrulle give the intermittency corrections to the structure functions of turbulence. The probability density function of the two-point statistics that can be compared to experiments and simulations turn out to be similar to the generalized hyperbolic distributions first suggested by Barndorff-Nilsen.

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MS8

Euler Equations on a Fast Rotating Sphere: Time-averages and Zonal Flows

Motivated by geophysical and planetary sciences, we investigate the barotropic, incompressible Euler equations on a fast rotating sphere S^2. We prove that the finite-time-average of the solution stays close to a subspace of longitude-independent zonal flows. The initial data can be arbitrarily far away from this subspace. Meridional variation of the Coriolis parameter underlies this phenomenon. Our proofs use Riemannian geometric tools, in particular the Hodge Theory.

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MS8

Nonlinear Dirac Equations in One Spatial Dimension

We consider the nonlinear Dirac equations in one dimension and review various results on global existence of solutions in H^1 and L^2. Depending on the character of the nonlinear terms, the large-norm solutions may exist for all times or may blow up in a finite time. We show that the small-norm solutions exist globally for the nonlinear Dirac equations with cubic and higher-order nonlinear terms. We also explain details of asymptotic stability of gap solitons in nonlinear Dirac equations with quintic and higher-order nonlinear terms

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MS8

Carrier Shocks Waves in Nonlinear and Nonlinear Media

Abstract not available at time of publication.

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MS9

The Affine Mean Curvature Flow of Convex Surfaces

Abstract not available at time of publication.

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MS9

Quantization Phenomena for Minimizing Sequences of the Willmore Functional

We consider a minimizing sequence of conformal immersions for the Willmore energy functional. We show that a quantization phenomenon arises. The sequence converges towards a Willmore immersion except at finitely many branch points, where the energy concentrates (by increments of 4π, according to the order of the branch). No energy is lost in the neck regions.

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MS9

Numerical Approximation of Anisotropic Willmore

Flow

Lately the analytical and numerical study of the Willmore functional

$$\mathcal{W}(-) = \frac{\infty}{\in} \int_{-} \mathcal{H}^{\in}$$

has received a lot of attention. In this work we provide a geometrically consistent definition of *anisotropic* Willmore functional and an appropriate FE-discretization for its flow. Our aim is to discover interesting (numerical) anisotropic Willmore surfaces.

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MS9
On the Helfrich Flow

The Helfrich flow is the steepest descent gradient flow in L^2 for the Helfrich functional, which for a closed immersed surface is a linear combination of the Willmore energy, surface area, and enclosed volume. In this talk we consider the global behaviour of the flow under an assumption of small initial Helfrich energy. We classify critical points of the functional and prove that the flow becomes asymptotic to a round point in finite time.

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MS10
Numerical Analysis of the Null Controllability of Thermoelastic Plate Dynamics

Semidiscrete finite difference and finite element approximation schemes are presented for the null controllability of those evolution equations which can be abstractly described by generators of analytic semigroups. The key feature here is that the null controllers being explicitly constructed exhibit the asymptotics of the associated minimal energy function. We focus here upon both "spectral" and "nonspectral" cases. Explicit PDE examples include fourth-order elastic equations subjected to either thermal or structural damping.

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MS10
Monotone Operator Theory and Applications to PDEs

In this talk, I will focus on the treatment of hyperbolic PDE's under the influence of *supercritical interior and boundary sources*. The local solvability of such problems is hopeless via standard fixed point theorems or Galerkin approximations, due to the lack of compactness. Also, it is well known that *most* solutions to such PDE's blow up in finite time. Therefore, from the viewpoint of stability, the presence of such sources necessitates the introduction of interior and/or boundary damping. On the other hand, it is well known that nonlinear dissipation in hyperbolic dynamics has been a source of many technical difficulties, especially when both interior and boundary feedback are present.
I will describe a general strategy that can handle the local solvability of most monotone problems by using nonlinear semi-groups (Kato's Theorem). However, nonlinear semi-groups can only accommodate a globally Lipschitz perturbation of a monotone problem. Thus, going from globally Lipschitz sources to the full generality of supercritical sources will require a great effort. In addition, I will discuss some recent results on convex integrals on Sobolev spaces which are essential to this strategy.

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MS10
Extremals of the Log Sobolev Inequality

The main purpose of the talk is to describe a counter example to the old question on existence of extremal of a standard Log Sobolev inequality (or its recent reincarnation in the form of Perelman's W entropy) on noncompact manifolds with bounded geometry. We also prove existence of extremal under an extra condition.

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MS11
High-Order Numerical Simulation of Vlasov Systems for Laser Plasma Interaction

We will report on our development of high-order algorithms for Vlasov systems for simulating laser-plasma interactions. Our approach is based on an explicit, high-order, nonlinear, finite-volume discretization that is discretely conservative, controls oscillations, and can explicitly enforce positivity. Adaptive mesh refinement will also be discussed. Results of physical significance will be presented in 1+1 and 2+2 dimensions and will include an analysis of the dynamics of externally driven plasma waves in two space dimensions.

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MS11
Reduced Resistive Models with Arbitrary Density

for Mhd in Tokamaks

Reduced resistive MHD models are useful to study MHD equilibrium in Tokamaks. I will discussed a new model with arbitrary density: this model is a extension of previous models. The so-called Current Hole instability will serve as an illustration. This work has been done with many colleagues: in particular Remy Sart and Shiva Malapaka.

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MS11

Nonlinear Landau Damping and Inviscid Damping

Consider electrostatic plasmas described by 1D Vlasov-Poisson system with a fixed ion background. In 1946, Landau discovered the linear decay of electric field near a stable homogeneous state. The nonlinear Landau damping was recently proved for analytic perturbations by Villani and Mouhot, and for general perturbations it is still largely open. With Chongchun Zeng, we construct nontrivial traveling waves (BGK waves) with any spatial period which are arbitrarily near any homogeneous state in $H^s(s < \frac{3}{2})$ Sobolev norm of the distribution function. Therefore, the nonlinear Landau damping is NOT true in $H^s(s < \frac{3}{2})$ spaces. We also showed that in small $H^s(s > \frac{3}{2})$ neighborhoods of linearly stable homogeneous states, there exist no nontrivial invariant structures. This suggests that the long time dynamics near stable homogeneous states in $H^s(s > \frac{3}{2})$ spaces might be much simpler. These results also hold true in 2D and 3D for a weighted Sobolev space. Besides, we obtained similar results for the problem of nonlinear inviscid damping of Couette flow, for which the linear decay was first observed by Orr in 1907.

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MS11

Analysis of the Three-Wave Coupling System for Laser-Plasma Interaction.

In the framework of Laser-Plasma interaction problems, one addresses the coupling between two electromagnetic waves (the transmitted and Brillouin backscattered ones) and an ion hydrodynamic wave. The characteristic speed of this last one is of course very small compared to the speed of light. We give new mathematical results on this non-linear hyperbolic system which is used for fourty years by physicists. Moreover we propose a numerical scheme and numerical illustrations.

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MS12

Mathematical Analysis of the Dimensional Scaling Technique for the Schrodinger Equation with Power-Law Potentials

The dimensional scaling (D-scaling) technique is an innovative asymptotic expansion approach to study multi-particle systems in chemical physics. It enables the calculation of ground and excited state energies of quantum systems without having to solve the Schrodinger equation. In this talk, the mathematical analysis of the D-scaling technique for the Schrodinger equation with power-law potentials is presented. By casting the D-scaling technique in an appropriate variational setting and studying the corresponding minimization problem, the D-scaling technique is justified rigorously.

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MS12

Bursting and Two-parameter Bifurcation in the Chay Neuronal Model

In this paper, we study and classify the firing patterns in the Chay neuronal model by the fast/slow decomposition and the two-parameter bifurcations analysis. We show that the Chay neuronal model can display complex bursting oscillations, including the "fold/fold" bursting, the "Hopf/Hopf" bursting and the "Hopf/homoclinic" bursting. Furthermore, dynamical properties of different firing activities of a neuron are closely related to the bifurcation structures of the fast subsystem. Our results indicate that the codimension-2 bifurcation points and the related codimension-1 bifurcation curves of the fast-subsystem can provide crucial information to predict the existence and types of bursting with changes of parameters.

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MS12

Proper Solutions to the Burgers-Huxley Equations

Many nonlinear partial equations arise in physical, chemical and biological contexts. Finding innovative methods to solve and analyze these equations has been an interesting subject in the field of partial equations and dynamical systems. In this talk, we are concerned with the Burgers-Huxley equations. Under certain conditions, we apply the higher terms in the Taylor series and the center manifold method to obtain the local behavior around a non-hyperbolic point of codimension one in the phase plane. Applying the Lie symmetry method we obtain some properties for proper solutions.

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MS12

Nonlinear Duffing-van der Pol Oscillator System

The nonlinear Duffing-van der Pol oscillator system is studied by means of the Lie symmetry reduction method and the Preller-Singer method. With the particular case of coefficients, this system has physical relevance as a simple model in certain flow-induced structural vibration problems. Under certain parametric conditions, we are concerned with the first integrals of the Duffing-van der Pol oscillator system. After making a series of variable transformations, we apply the Preller-Singer method and the Lie symmetry reduction method to obtain the first integrals of the simplified equations without complicated calculations.

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MS12

Optimal Regularity for A-Harmonic Type Equations under the Natural Growth

In this talk, we show that each bounded weak solution of A-harmonic type equations under the natural growth belongs to locally Hölder continuity based on a density lemma and Moser-Nash's argument. Then we show that its weak solution is of optimal regularity with the Hölder exponent for any γ: $0 \leq \gamma < \kappa$, where κ is the same as the Hölder's index for homogeneous A-harmonic equations.

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MS13

Partial Regularity for Higher Dimensional Navier-Stokes Equations

I will discuss some recent results about partial regularity and a regularity criterion for higher dimensional Navier-Stokes equations. The talk is based on joint work with Dapeng Du and Robert Strain.

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MS13

Leonardo vs. Kolmogorov; 3D Enstrophy Cascade

Existence of 2D enstrophy cascade in a suitable mathematical setting – and under suitable conditions compatible with 2D turbulence phenomenology – is known both in the Fourier and in the physical scales. The goal of this talk is to show that the same geometric condition preventing the formation of singularities ($\frac{1}{2}$-Holder coherence of the vorticity direction), coupled with a 2D-like condition for the enstrophy cascade, and under a certain modulation assumption on evolution of the vorticity, leads to existence of 3D enstrophy cascade in physical scales of the flow.

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MS13

Local Existence and Uniqueness of the Solutions to the Free Boundary Value Problem for the Ocean

In this talk, we consider the free boundary value problem for the primitive equations of the atmosphere and the ocean model, which has been proposed by Lions, Temam, and Wang. We establish that the initial value problem is well-posed in the space of real analytic functions. Namely, we prove the local existence of a unique real analytic solution. This is a joint work with Igor Kukavica and Mohammed Ziane.

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MS13

Boundary Layer Analysis of the Navier-Stokes Equations with Generalized Navier Boundary Conditions

Using generalized Navier boundary conditions, in which the friction parameter is replaced by a tensor on the boundary, we obtain a boundary layer expansion for solutions to the Navier-Stokes equations for small viscosity in a 3D bounded domain. As a result, we obtain convergence in the energy norm and uniformly in time and space, with bounds on the convergence rate, for solutions of the Navier-Stokes equations to a solution to the Euler equations.

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MS13

Convection-diffusion Equations with Small Viscosity in a Circle

In this talk we will discuss singular perturbation problems for convection-diffusion equations in a circle when the viscosity is small. Highly singular behaviors can occur at the characteristic points which render the analysis difficult. A detailed analysis of these singularities has been conducted, and the corresponding boundary layers have been made explicit. This simplified model shows how singular and involved the behaviors can be in incompressible fluid mechanics when the viscosity is small.

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MS14

A Pressure-stabilized Characteristics Finite Element Scheme for the Navier-Stokes Equations and Its Application to a Thermal Convection Problem

Recently, we have developed a combined finite element scheme with the method of characteristics and a pressure stabilization for the Navier-Stokes equations. The scheme has such advantages that the coefficient matrix of the system of the linear equations is symmetric and it is useful for large scale computations. In this paper, we show usefulness of the scheme and give a characteristics finite element scheme for a thermal convection problem with its numerical results.

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MS14
Finite Difference Methods for Blow-up Problems

We consider a scalar semi-linear parabolic partial differential equation $u_t = u_{xx} + f(u)$ $(0 \le t, 0 \le x \le 1)$ and related equations, where $f : \mathbf{R} \to \mathbf{R}$ is a smooth function. It is known that a solution with a large initial data may blow up in finite time, if an appropriate growth condition on f as $u \to \infty$ is imposed. We are concerned with a question as to how a finite difference scheme can reproduce the blow-up phenomena. We generalize some results in C.-H. Cho, S. Hamada, and H. Okamoto, On the finite difference approximation for a parabolic blow-up problem, *Japan J. Indut. Appl. Math.*, **24** (2007), 131–160.

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MS14
L^1 Analysis of the Finite Volume Method for Nonlinear Degenerate Diffusion Problems

We consider a degenerate parabolic equation $u_t - \Delta f(u) = 0$ in a bounded domain Ω with the homogeneous Dirichlet boundary condition. Here, f denotes a non-decreasing continuous function satisfying $f(0) = 0$. We shall see that FVM is a suitable discretization method for the equation in the sense that the discrete version of the L^1 theory of Brezis and Strauss can be applied. This is totally new approach to study FVM for degenerate parabolic problems.

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MS14
Mean Curvature Flow with Volume Constraint

An approximation for the volume-constrained multiphase mean curvature flow will be presented. A thresholding method based on the idea of the MBO algorithm is used and theoretical and computational aspects of the global constraint are discussed. The ultimate goal is to simulate the motion of bubbles or droplets touching each other and/or a rigid boundary and to analyze the corresponding evolutionary free-boundary problem.

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MS15
Variational Methods in Image Processing

Deblurring, denoising, inpainting and recolorization of images are fundamental problems in image processing and have given rise in the past few years to a vast variety of techniques and methods touching different fields of mathematics. Among them, variational methods based on the minimization of certain energy functionals have been successfully employed to treat a fairly general class of image restoration problems. The underlying theoretical challenges are common to the variational formulation of problems in other areas. Here first order RGB variational problems for recolorization will be analyzed, and the use of second order variational problems to eliminate the staircasing effect will be validated.

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MS15
Hybrid Methods for Keller-Segel-Patlak Type of Equations

We describe an implicit scheme to approximate the solution of the Keller-Segel-Patlak system. There are several issues related to the convergence of this scheme whose status we discuss.

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MS15
Reversible Description of Coagulation and Fragmentation

The process of coagulation is associated with scalar conservation laws, where the adhesion particle dynamics results from shock waves. Conversely, the fragmentation of a massive particle is associated with rarefaction waves. It is shown that both coagulation and fragmentation may coexist for a reversible solution, under a natural generalization of the system of conservation law. This is done by the introduction of an action principle which includes an internal energy.

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MS15
On the Ramified Optimal Allocation Problem

We propose an optimal allocation problem with ramified transport technology in a spatial economy. Ramified transportation is used to model the transport economy of scale in group transportation observed widely in both nature and efficiently designed transport systems of branching structures. The ramified allocation problem aims at finding an optimal allocation plan as well as an associated optimal allocation path to minimize overall cost of transporting commodity from factories to households. We develop methods of marginal transportation analysis and projectional analysis to study properties of optimal assignment maps. These properties are then related to the search for an optimal assignment map in the context of state matrix. A joint work with Shaofeng Xu.

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MS16

Finite Element Clifford Algebra: A New Toolkit for Evolution Problems

This talk will introduce a new toolkit for the design of stable finite element methods for evolution equations using the geometric theory provided by Clifford algebras. Building on the viewpoint from Arnold, Falk and Winther's finite element exterior calculus, I will show how the broader theory of geometric calculus (a type of Clifford algebra) can be used to coherently describe and discretize time-like dimensions in evolutionary problems. Applications of this perspective to specific problems from molecular biology will be discussed.

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MS16

Geometric Variational Crimes: Hilbert Complexes, Finite Element Exterior Calculus, and Problems on Hypersurfaces

The success of mixed finite element methods is deeply connected with differential geometry and algebraic topology—particularly with the exterior calculus of differential forms. The notion of 'Hilbert complex,' rather than 'Hilbert space,' provides the appropriate functional-analytic setting for these methods. This talk will present recent results that analyze 'variational crimes' (a la Strang) on Hilbert complexes; as a corollary, this work also generalizes several key results on 'surface finite elements' for elliptic PDEs on hypersurfaces.

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MS16

Adaptive Boundary Element Methods with Convergence Rates

Boundary element methods (BEM) are a way to numerically solve elliptic boundary value problems by reformulating them as singular integral equations on the boundary of the domain, and by applying finite element (FEM) type methods to the resulting integral equations. This is very convenient and leads to potentially efficient computational schemes since now the unknown function lives on a manifold with dimension one less than that of the original domain. However, in order to arrive at an efficient working computer code that is backed up by a sound mathematical theory, one has to overcome some major algorithmic and analytic hurdles, in addition to the problems encountered in the corresponding FEM setting. Although most of these hurdles have been successfully attacked so that the whole situation is about as satisfactory as with FEM, there still remain a few glaring exceptions including the convergence theory of adaptive BEM. The difficulties are related to the non locality of the involved integral operators and fractional order Sobolev norms. For instance, geometric error reduction for adaptive BEM has been rigorously established so far only under the so-called saturation assumption, whereas the first such proof without saturation assumption for an adaptive FEM in 2D was published in 1996. This contribution is an attempt to fill this gap by developing a set of techniques that is able to prove geometric error reduction and quasi-optimal convergence rates for adaptive BEM, without relying on saturation type assumptions. The main ingredients of the proof are some new results on local *a posteriori* error estimates for boundary element methods, and inverse-type inequality involving boundary integral operators on locally refined finite element spaces.

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MS16

A Priori Estimates and Adaptive Methods for Geometric Partial Differential Equations

In this talk, we present an approximation theory framework the use of adaptive finite element approximation techniques for the constraints arising in the Einstein equations in general relativity. We first summarize recent work on apriori max-norm estimates, sub- and super-solutions, and existence theory for this system of elliptic equations. We then develop a discrete analogue of the existence argument and a priori estimates for the Petrov-Galerkin discretization. Based on this approximation theory framework, we develop a nonlinear approximation algorithm based on error indicator-driven refinement of simplex triangulations of the domain. We show that the adaptive algorithm converges for the Hamiltonian constraint, and establish that the overall algorithm has optimal (linear) complexity in the number of degrees of freedom.

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MS17

Longtime Behavior of Fluid-structure PDE Dynamics

In this talk we shall derive certain delicate decay rates for a partial differential equation (PDE) systems which comprise couplings of parabolic with hyperbolic dynamics. The appearances of such coupled PDE models in the literature are well-established, inasmuch as they mathematically govern many physical phenomena; e.g., structural acoustic flow fields, or the immersion of an elastic structure within a fluid. The coupling between the distinct hyperbolic and parabolic dynamics typically occurs at the boundary interface between the media. In previous work, we have established semigroup wellposedness for such dynamics, in part through a nonstandard elimination of the associated pressure variable. For this PDE model, we provide a uniform rational decay estimate for solutions corresponding to smooth initial data; viz., for initial data in the domain of the semigroup generator. The attainment of this result depends upon the appropriate use of a recently derived operator semigroup result of A. Borichev and Y. Tomilov.

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MS17

Non-aircraft Applications of Aeroelastic Flutter

We report on our recent experimental work on a low-speed wind-tunnel on non-aircraft applications of Aeroelastic Flutter: Optimizing Piezoelectric Power generation from ambient wind.

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MS17

Surface Waves for Hyperbolic Systems of PDE

Hyperbolic systems with conservative boundary conditions in a half space are considered. Usually, these boundary problems do not satisfy the Kreiss-Sakamoto condition (uniform Lopatinskii condition); hence, there may exist non-trivial solutions to the homogeneous boundary problem. These solutions can be described as surface waves of either finite energy or of infinite energy. Elementary properties of surface waves will be discussed. The most important example is the Rayleigh wave in elastodynamics.

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MS17

Controllability of a Membrane or Plate Enclosing a Potential Fluid

We consider a fluid-filled container with a rigid portion and an elastic portion of the boundary. We assume a simple potential fluid model, with linearized coupling to the membrane at the equilibrium configuration. We show that if the fluid density is sufficiently small, then exact controllability results similar to the results for the completely uncoupled system hold. For example, in the case of a two-dimensional membrane enclosing a three-dimensional fluid, it is enough to control a sufficiently large portion of the (one-dimensional) boundary of the flexible membrane. This result however, is not a simple perturbation result since even in the case of a zero fluid density, there remain nonlocal constraints imposed on the elastic system. We also discuss some related controllability results for a 2-dimensional cochlea model consists of a one-dimensional elastic structure (modeling the basilar membrane) surrounded by an incompressible 2-dimensional fluid.

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MS17

Controllability of the Foppl-von Karman Elastic Shells with Residual Strain

The prestrained von-Karman system is a version of the von-Karman equations of nonlinear elasticity, proposed by Mahadevan and Liang as a description of morphogenesis of naturally growing thin tissues (leaves, flowers) at a specific regime of the magnitude of internal strain. The same system has been then rigorously derived, starting from the 3d nonlinear non-Euclidean elasticity, by Lewicka, Mahadevan and Pakzad. We discuss questions related to controllability and stability of this system.

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MS18

Title Not Available at Time of Publication

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MS18

On the L_1-Stability and Instability of the Boltzmann and Vlasov-Poisson Equations

In this talk, I will present a recent progress on the uniform L^1-stability and instability of the two prototype kinetic equations (the Boltzmann and Vlasov-Poisson(V-P) system). For the V-P system in high dimensions ($d \geq 4$), the small amplitude decaying solutions are uniformly L^1-stable due to the strong dispersion property of the corresponding linearized equation, while for three dimensions, such an uniform L^1-stability estimate for the V-P system is still not known even for small solutions. I will report two negative results on the non-existence of L^1-asymptotic completeness and instability of compacton solution for the V-P system in three dimensions, which might suggest the possible scenario for the L^1-instability of the Vlasov-Poisson system in three dimensions. This is a joint work with Sun-Ho Choi (SNU).

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MS18

Weak Shock Diffraction

We study an asymptotic problem that describes the diffraction of a weak, self-similar shock near a point where its shock strength approaches zero and the shock turns continuously into an expansion wavefront. An example arises in the reflection of a weak shock off a semi-infinite screen. The asymptotic problem consists of the unsteady transonic small disturbance equation with suitable matching conditions. We obtain numerical solutions of this problem, which show that the shock diffracts nonlinearly into the expansion region. We also solve numerically a related half-space problem with a "soft' boundary, which shows a complex reflection pattern similar to one that occurs in the Guderley Mach reflection of weak shocks.

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MS18

Shock Formation in the Plane

In classical pictures of steady transonic flow (for example, a compression wave over an airfoil), it appears that the shock forms exactly on the sonic line. However, careful numerical simulations on this and on a corresponding situation in unsteady two-dimensional flows reveal that the shock actually forms at a point where the underlying system (steady or self-similar) is strictly hyperbolic. What is in fact the case? I will talk about joint work with Allen Tesdall that shows (by means of a simple example) that a transonic shock can indeed be created on the sonic line. However, the set-up appears to be structurally unstable, and a small perturbation will displace it into the hyperbolic region. This explains both the appearance of such shocks and the fact that under sufficient numerical resolution they appear to move off the sonic line.

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MS18

Particle Behaviors in Strained Turbulence

Our work discusses the effect of straining on particles in turbulence. Turbulent flows are simulated with the Direct Numerical Simulation method, and the Rogallo algorithm is applied to deal with domain variations from strain over time. We study the behaviors of inertial particles by simulating movements of particles with inertia. Distributions and probability density functions of velocities and accelerations of particles with different Stokes numbers under different strain rates will be presented.

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MS19

Eco-evolutionary Dynamics: Advances and Challenges

The ecological dynamics of populations and evolutionary dynamics of species have traditionally been modeled on different timescales and with different classes of equations. Realizing that this was an artificial distinction with no solid biological justification had led the development over the last decade of new eco-evolutionary dynamics models in which evolutionary processes shape ecological systems and ecological dynamics feed back on evolution. Here we will review the state of the art about how to construct eco-evolutionary dynamics models from microscopic processes taking place at the level of individuals. We will outline some major biological advances made possible, and challenges raised, by the mathematical and numerical analysis of eco-evolutionary dynamics models.

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MS19

Selection-mutation Dynamics

We consider a integro-difffferential nonlinear model that describes the evolution of a population structured by a quantitative trait. The interactions between traits occur from competition for resources whose concentrations depend on the current state of the population. Corrections taking the effects of small populations are also introduced. We study a concentration phenomenon arising in the limit of strong selection and small mutations.

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MS19

Dirac Mass Dynamics in Parabolic Equations

Nonlocal Lotka-Volterra models have the property that solutions concentrate as Dirac masses in the limit of small diffusion. Is it possible to describe the dynamics of the concentration points and of the mass of the Dirac? We will explain how this relates to the so-called 'constrained Hamilton-Jacobi equation' and how numerical simulations can exhibit unexpected dynamics well explained by this equation. Our motivation comes from 'populational adaptive evolution' a branch of mathematical ecology which models the darwinian evolution.

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MS19

Populations Structured by a Phenotypic Trait and a Space Variable

Together with Sepideh Mirrahimi, I investigated a structured population model where the population is structured by both a phenotypic trait and a space variable. The population endures a classical mutation-selection effect locally, and diffuses in space. From this kinetic model, we are able to derive a PDE model introduced by N. Barton and M. Kirkpatrick (and thus enlight the conditions necessary for this model to apply). Finally, we analyse further this model.

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MS20

Isometric Embedding and BV Weak Solutions

The isometric immersion problem for surfaces embedded into R^3 is studied via a fluid dynamic formulation as a system of balance laws. Local and global existence results are established for weak solutions of small bounded variation to the Gauss–Codazzi system for negatively curved surfaces that admit equilibrium configurations. As an application, the case of catenoidal shell of revolution is provided.

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MS20

Shock Profiles in Radiative Hydrodynamics: Formation of Zeldovich Spikes

We shall present some results on the existence of shock profiles for a model of radiative hydrodynamics that couples the compressible Euler equations with an elliptic equation for the radiation energy density. When the shock amplitude is small, previous works have shown the existence and stability of smooth and monotone traveling waves. Here we present an existence result in the case of large amplitude shock waves. In particular we give a rigorous justification to the formation of so-called Zeldovich spikes, meaning that the temperature profile exhibits an overshoot behind the shock. This is a joint work with T. Goudon, P. Lafitte and C. Lin.

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MS20

Shock Reflection and Free Boundary Problems

Shocks in gas or compressible fluid arise in various physical situations, and often exhibit complex structures, which present fundamental multidimensional phenomena in hyperbolic conservation laws. One example is reflection of shock by a wedge. Experimental and computational works have shown that various patterns of reflected shocks may occur, including regular and Mach reflection. In this talk we discuss some results on existence, regularity and geometric properties of regular reflection solutions for potential flow equation. The approach is to reduce the shock reflection problem to a free boundary problem for a nonlinear equation of mixed elliptic-hyperbolic type. Open problems will also be discussed.

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MS20

Instability Theory of Navier-Stokes-Poisson System

We establish a linear and a nonlinear instability for the Lane-Emden solutions of the Navier-Stokes-Poisson system for $6/5 < \gamma < 4/3$ in the spherically symmetric motion. This is a joint work with Ian Tice.

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MS20

Dynamics of a Density Discontinuity in Compressible, Viscous Fluid Flows

In this talk we will discuss some geometric properties of an interface of jump discontinuity of the density of a fluid flow in the model of the Navier-Stokes equations. We show that at the points where the interface meets the boundary, where the flow is subjected to Navier boundary conditions, the velocity field has a weak singularity that instantaneously changes the type of the tangency from transversal to tangent.

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MS21

Strichartz Estimates in Polygonal Domains

Strichartz inequalities are a family of space time L^p estimates for the wave equation in that rely on the decay properties of solutions. They are of interest due to their applications to nonlinear equations. These estimates are best understood when the equation is posed over all of Euclidean space. However, the situation is more intricate when one starts to consider boundary value problems. This is due to the fact that boundary conditions affect the flow of energy. When the equation is posed on a polygonal domain, diffractive effects coming from interaction with the corners further complicate matters. Nonetheless, we will see that such inequalities are valid in this context. This is a joint work with G.A. Ford and J. Marzuola.

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MS21

Wave Propagation on Square Lattices

We study dispersive estimates for the wave equation on a square lattice with non-isotropic coupling between nodes. Areas of minimal dispersion occur at critical values of the velocity function for plane waves, with the time-decay exponent determined by the type of degeneracy present at the critical value. For the two-dimensional lattice, there exists a unique velocity (up to mirror symmetries) along which wavefronts propagate with amplitude $|t|^{-3/4}$.

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MS21

Phase-driven Interaction of Widely Separated Nonlinear Schroedinger Solitons

We show that, for the 1d cubic NLS equation, widely separated equal amplitude in-phase solitons attract and opposite-phase solitons repel. Our result gives an exact description of the evolution of the two solitons valid until the solitons have moved a distance comparable to the logarithm of the initial separation. Our method does not use the inverse scattering theory and should be applicable to nonintegrable equations with local nonlinearities that support solitons with exponentially decaying tails. The result is presented as a special case of a general framework which also addresses, for example, the dynamics of single solitons subject to external forces.

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MS21

Bounds on the Growth of High Sobolev Norms of Solutions to Nonlinear Schroedinger Equations

Abstract not available at time of publication.

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MS22

A Generalized Rayleigh-Taylor Condition for the Two Phase Muskat Problem

The evolution of two fluid phases in a porous medium is studied. Two free interfaces which evolve in time separate the fluids from each other and the wetting phase from the air, respectively. The full problem is reduced to an abstract evolution equation for the interfaces. A generalised Rayleigh-Taylor condition characterizes the parabolicity regime of the problem and allows to establish a general well-posedness result and to study stability properties of flat steady-states. When considering surface tension effects at the interface between the fluids and when the less dense fluid lies beneath, bifurcating finger-shaped equilibria are shown to exist which are however all unstable.

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MS22

On the Navier-Stokes Problem in Exterior Domains with Non-decaying Initial Data

We study the existence and uniqueness of regular solutions to the Navier-Stokes initial-boundary value problem with non-decaying bounded initial data, in a smooth exterior domain of R^n, $n \geq 3$. The pressure field, p, associated to these solutions may grow, for large $|x|$, as $O(|x|^\gamma)$, for some $\gamma \in (0,1)$. Our class of existence is sharp for well posedeness, in that we show that uniqueness fails if p has a linear growth at infinity. We also provide a sufficient condition on the spatial growth of ∇p for the boundedness of v, at all times. Also this latter result is shown to be sharp.

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MS22

Analysis of the Spin-coating Process

In this talk we investigate analytically the evolution of a small drop of liquid which is placed on the center of a rotating disc. Considering the above problem as a one- or two-phase free boundary value problem for Newtonian or generalized Newtonian fluids subject to surface tension and rotational forces, we prove that $T > 0$ there exists a unique, strong solution to this problem on $(0, T)$ provided the data are small enough is suitable norms.

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MS22

Stochastic Stability of the Ekman Spiral

We consider the Navier-Stokes equations with Coriolis term with periodic boundary conditions perturbed by a cylindrical Wiener process. Weak and stationary martingale solutions to the associated stochastic evolution equation are constructed. The time-invariant distribution of the stationary martingale solution can be interpreted as the long-time statistics of random fluctuations of the stochastic evolution around the Ekman spiral, which is an explicit stationary solution of the Navier-Stokes equations with Coriolis term.

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MS23

Homogenization of $L^inf ty$ Variational Problems in Random Media

In joint work with Souganidis, we introduce a new compari-

son principle for Eikonal equations in exterior domains. As a consequence, we are able to homogenize L^∞ variational problems (and in particular the Aronsson equation) in self-averaging (i.e., periodic, almost periodic, and stationary ergodic) environments.

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MS23

Existence and Duality for L^∞ Optimal Transport

I will discuss an existence result (obtained in collaboration with Thierry Champion and Petri Juutinen) for the optimal transportation problem in which the cost is given by the essential sup instead of an integral. I will point at some evidence that, although the problem is not convex, there must be some kind of hidden duality. I will propose some recent development in this direction.

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MS23

American Option Tug-of-War and the Infinity Laplacian; A Free Boundary Problem

We consider American option tug-of-war and its application to the problem of proving the existence of extensions of boundary functions satisfying the infinity Laplacian equation which are constrained to lie above an obstacle. We consider the usual two player tug-of-war game played in ffl discs with the added constraint that one player may end the game at any time and collect the value of the obstacle function. We prove that the limit as εffl tends to 0 satisfies the infinity Laplacian equation.

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MS23

Calibration Method for Infinity Harmonic Functions

In this talk, I will describe a calibration scheme corresponding to infinity harmonic functions and illustrate an application to the removable isolated singularity of infinity harmonic functions. This is a joint work with Thierry De Pauw.

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MS24

Magnetic Interaction Morawetz Estimates and Applications

We establish an interaction Morawetz estimate for the magnetic Schrödinger equation under certain smallness conditions on the gauge potentials. We discuss applications to wellposedness and scattering.

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MS24

A Factorization Method for a Non-symmetric Linear Operator: Enlargement of the Functional Space while Preserving Hypo-coercivity.

We present a factorization method for non-symmetric linear operators: the method allows to enlarge functional spaces while preserving spectral properties for the considered operators. In particular, spectral gap and related convergence towards equilibrium follow easily by hypocoercivity and resolvent estimates. Applications of this theory to several kinetic equations will be presented.

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MS24

On Aleksandrov-Bakelman-Pucci Type Estimates for Integro-Differential Equations (comparison theorems with measurable ingredients)

Despite much recent (and not so recent) attention to solutions of integro-differential equations of elliptic type, it is surprising that a fundamental result such as a comparison theorem which can deal with only measure theoretic norms of the right hand side of the equation (L-n and L-infinity) has gone unexplored. For the case of second order equations this result is known as the Aleksandrov-Bakelman-Pucci estimate (and dates back to circa 1960s), which says that for supersolutions of uniformly elliptic equation Lu=f, the supremum of u is controlled by the L-n norm of f (n being the underlying dimension of the domain). We discuss extensions of this estimate to fully nonlinear integro-differential equations and present a recent result in this direction. (Joint with Nestor Guillen, available at arXiv:1101.0279v [math.AP])

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MS24

Global Solutions to a Non-local Diffusion Equation with Quadratic Non-linearity

In this talk we will present our recent proof of the global in time well-posedness of the following non-local diffusion equation with $\alpha \in [0, 2/3)$:

$$\partial_t u = \left\{ (-\triangle)^{-1} u \right\} \triangle u + \alpha u^2,$$

The initial condition is positive, radial, and non-increasing; these conditions are propagated by the equation. There is however no size restriction on the initial data. This model problem is of interest due to its structural similarity with Landau's equation from plasma physics, and moreover its radically different behavior from the semi-linear Heat equation with quadratic non-linearity. This is a joint work with Joachim Krieger.

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MS25

The Vortex-Wave Equation as the Limit of the Euler Equation

The Wave-Vortex system was introduced by Marchioro and Pulvirenti to model point vortex motion in an inviscid fluid. It consists of a PDE describing the vorticity of the inviscid fluid coupled to ODEs that describe the point vortex motion. In this talk we will discuss the physical justification for such a model. In particular, we will discuss how a sequence of solutions for the Euler equation in the plane converges to a solution of the Vortex-Wave equation.

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MS25

Self-similar Asymptotics of Solutions to Navier-Stokes System in Two Dimensional Exterior Domain

We show how to construct a family of initial velocities such that the large time behavior of corresponding solutions to the initial-boundary value problem for Navier-Stokes equations in a two dimensional exterior domain is described by the Lamb-Oseen vortex. The later is the well-known explicit self-similar solution to the Navier-Stokes system in the whole space $\mathbf{R}^2$.

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MS25

Weak Solutions to the Vortex-Wave System

The vortex-wave system is the coupling of the 2D vorticity equation with the point vortex system. In 2009, Lacave and Miot proved uniqueness of weak solutions to this system for initial configurations where the continuous part of the vorticity is constant near the initial position of the point vortices. There have been several developments following Lacave and Miot's work, which include existence of weak solution for initial vorticity in L^p and convergence of approximations coming from the vortex blob method, by C. Bjorland. In this talk, we report on two new results: convergence of approximations coming from the Euler-α system, joint work with E. de Moura, and existence of particle trajectories for the L^p weak solutions.

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MS25

Vortex Layers of Small Thickness

In this talk we shall treat the case of a planar inviscid flow with initial datum of vortex layer-type: vorticity of $O(\epsilon^{-1})$ is concentrated on a layer of thickness ϵ in such a way that, in the limit $\epsilon \to 0$, the vorticity distribution converges to a δ-function concentrated on a curve. In an analytic functional setting we shall prove that the Euler equation are well-posed for a time that does not depend on the thickness of the layer. This is a generalization of the result of D.Benedetto and M.Pulvirenti, SIAM J. Appl. Math. 52 (1992), where the authors considered the case of vortex layers of uniform vorticity. We shall also discuss the possibility of using our result as a step toward the justification of the Birkhoff-Rott equation starting from the Navier-Stokes equations.

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MS26

On a Critical Leray-alpha Model of Turbulence: Regularity and Singularity Issues

In this talk, we prove the existence of a unique weak solution to turbulent flows governed by the Leray-alpha model with critical regularization. When alpha tends to zero,we prove that the Leray alpha solution, with critical regularization,givesrise to a suitable solution to the Navier Stokes equations. We consider also the subcritical case where we establish the upper estimate of the Hausdorff dimension of the possible times at which the singularity can occur.

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MS26

A New Blow-up Criterion for the 2D Boussinesq and 3D Euler Equations: Analytical and Numerical Results

Recently, the Voigt-regularization–related to the alpha-models of turbulent flows–has been investigated as a regularization of various fluid models. It overcomes many of the problems present in other alpha-models. Moreover, in studying the limit as the regularization parameter tends to zero, a new criterion for the finite-time blow-up of the original equations arises. I will discuss recent analytical and numerical work on the Voigt-regularization in the context of the 3D Euler and 2D Boussinesq equations.

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MS26

Global well-posedness for the 2D Boussinesq System without Heat Diffusion with Anisotropic Vis-

cosity

In this talk I will discuss global existence and uniqueness theorems for the two-dimensional non-diffusive Boussinesq system with viscosity only in the horizontal direction. In proving the uniqueness result, we have used an alternative approach by writing the transported temperature (density) as $\theta = \Delta\xi$ and adapting the techniques of V. Yudovich for the 2D incompressible Euler equations. This new idea allows us to establish uniqueness results with fewer assumptions on the initial data for the transported quantity θ. Furthermore, this new technique allows us to establish uniqueness results without having to resort to the paraproduct calculus of J. Bony.

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MS26

Improving Accuracy in Alpha Models of Incompressible Flows via Adaptive Nonlinear Filtering

The alpha-models of fluid flow have many attractive mathematical and physical properties compared to other commonly used models, making their use desirable. However, when used to get coarse-mesh approximations of physical phenomena, their solutions often lack sufficient accuracy, typically due to over-regularization. This talk will discuss strategies based on turbulence phenomenology that help to avoid this problem and thus give more accurate solutions, by locally tuning regularization through nonlinear filtering with indicator functions. Several numerical examples will be presented to illustrate the effectiveness of the proposed methods.

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MS26

Partial Regularity Results for Generalized Alpha Models of Turbulence

This talk is on an extension of the analysis of Katz and Pavlović on partial regularity of hyper-dissipative Navier-Stokes equations, to include cases where the nonlinear term is suitably regularized. This family captures most of the specific regularized alpha-type models that have been proposed and analyzed in the literature, including the the Navier-Stokes-alpha model, the Leray-alpha model, the modified Leray-alpha model, and certain MHD-alpha models, etc. The bounds are functions of the spatial dimension and of the three parameters characterizing the principal smoothing operators, and we recover the Katz-Pavlović results in 3 dimension and for one specific combination of the three remaining parameters.

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MS27

Limiting PDEs of a Vicsek-type Flocking Model

Interacting particle models have been widely applied in recent years, particularly for simulating the collective dynamics of many cooperative organisms. These models present interesting mathematical challenges, since the number of interacting organism is often quite large. As the system becomes larger, it becomes more expensive to use interacting particles and so the question lies in how to describe the complex dynamics at a macroscopic level without losing important microscopic effects. Here, we will formally derive limiting PDEs for a model that has been used to study fish schooling and other flocking dynamics.

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MS27

A Primer of Swarm Equilibria

We study equilibrium configurations of swarming biological organisms subject to exogenous and pairwise endogenous forces. Beginning with a discrete dynamical model, we derive a variational description of the continuum population density. Equilibrium solutions are extrema of an energy functional, and satisfy a Fredholm integral equation. We find conditions for the extrema to be local minimizers, global minimizers, and minimizers with respect to infinitesimal Lagrangian displacements of mass. In one spatial dimension, for a variety of exogenous forces, endogenous forces, and domain configurations, we find exact analytical expressions for the equilibria. These agree closely with numerical simulations of the underlying discrete model.The exact solutions provide a sampling of the wide variety of equilibrium configurations possible within our general swarm modeling framework. The equilibria typically are compactly supported and may contain δ-concentrations or jump discontinuities at the edge of the support. We apply our methods to a model of locust swarms, which are observed in nature to consist of a concentrated population on the ground separated from an airborne group. Our model can reproduce this configuration; quasi-two-dimensionality of the model plays a critical role.

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MS27

Swarm Dynamics and Equilibria for a Nonlocal Aggregation Model

We consider the aggregation equation $\rho_t - \nabla\cdot(\rho\nabla K * \rho) = 0$ in R^n, where the interaction potential K models short-range repulsion and long-range attraction. We study a family of interaction potentials for which the equilibria are of finite density and compact support. We show global well-posedness of solutions and investigate analytically and numerically the equilibria and their global stability. In particular, we consider a potential for which the corresponding equilibrium solutions are of uniform density inside a ball of R^n and zero outside. For such a potential, various explicit calculations can be carried out in detail. In one dimension we fully solve the temporal dynamics, and in two or higher dimensions we show the global stability of this steady state within the class of radially symmetric solutions.

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MS27

Mathematical Models for Phototaxis

Certain organisms undergo phototaxis, that is they migrate toward light. In this talk we will discuss our recent results on modeling phototaxis in order to understand the functionality of the cell and how the motion of individual cells is translated into emerging patterns on macroscopic scales. This is a joint work with Amanda Galante, Susanne Wisen, Tiago Requeijo, and Devaki Bhaya.

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MS28

Singularity Formations for a Surface Wave Model

In this talk we discuss the Burgers equation with a Hilbert transform. This system has been considered as a quadratic approximation for the dynamics of a free boundary of a vortex patch. We prove blow-up in finite time for a large class of initial data with finite energy.

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MS28

Pressure Beneath a Periodic Traveling Water Wave

Consider periodic two-dimensional gravity water waves propagating in irrotational flow at constant speed at the surface of water with a flat bed. Then the pressure in the fluid strictly decreases horizontally away from the crest line and strictly increases with depth. Moreover, along each streamline the horizontal velocity strictly decreases away from the crest line. These results have been obtained as joint work with Walter Strauss.

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MS28

Stability of Current Vortex Sheets in Incompressible Magnetohydrodynamics

We consider the free boundary problem for current-vortex sheets in ideal incompressible magneto-hydrodynamics. It is known that current-vortex sheets may be at most weakly (neutrally) stable due to the existence of surface waves solutions to the linearized equations. The existence of such waves may yield a loss of derivatives in the energy estimate of the solution with respect to the source terms. However, under a suitable stability condition satisfied at each point of the initial discontinuity and a flatness condition on the initial front, we prove an a priori estimate in Sobolev spaces for smooth solutions with no loss of derivatives. The result of this paper gives some hope for proving the local existence of smooth current-vortex sheets without resorting to a Nash-Moser iteration. Such result would be a rigorous confirmation of the stabilizing effect of the magnetic field on Kelvin-Helmholtz instabilities, which is well known in astrophysics.

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MS28

Stability Issues for Interfacial Flows

We analyze various mechanisms of the propagation of interfacial waves (such as Kelvin-Helmholtz instabilities) and show how these mechanisms allow us to explain various physical phenomena, and in particular internal waves in the ocean.

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MS29

Asymptotic Analysis of the Navier-Stokes Equations in a General Bounded Domain with Noncharacteristic Boundaries

We consider the Navier-Stokes equations of an incompressible fluid, when the viscosity is small, in a three dimensional curved domain with permeable walls. Thanks to the curvilinear coordinate system, adapted to the boundary, we construct corrector functions which allow us to obtain asymptotic expansions of the Navier-Stokes solutions. Then, using the asymptotic expansions, we prove that the Navier-Stokes solutions converge, as the viscosity parameter tends to zero, to the corresponding Euler solution in the natural energy norm.

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MS29

Boundary Layer Correctors for Curved Boundaries

I discuss the use of principal curvature coordinates in the construction of boundary layer correctors, discussing, as a specific example, the corrector for the Navier-Stokes Equations with generalized Navier boundary conditions.

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MS29

Global Existence for the Dissipative Critical Surface Quasi-geostrophic Equation

PIn this talk, we study the critical dissipative (SGQ) equation. We show the global existence for large initial data in a space close to the space of uniformally locally square integrable functions. The proof is based on an energy inequality verified by the truncated and regularized equation.

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MS29

Initial and Boundary Value Problems for Some Equations from Geophysical Fluid Mechanics

In this lecture we present some existence and uniqueness results for initial and boundary value problems for the linearized two-dimensional inviscid shallow water equations in a rectangle. We will also give some indications on the nonlinear equation in space dimension one.

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MS29

Examples of Boundary Layers Associated with the Incompressible Navier-Stokes Equations

Boundary layer associated with slightly viscous fluid is one of the most challenging problem in applied analysis and fluid mechanics. We survey a few examples of boundary layers for which the Prandtl boundary layer theory can be rigorously validated. All of them are associated with the incompressible Navier-Stokes equations for Newtonian fluids equipped with various Dirichlet boundary conditions (specified velocity). These examples include a family of (nonlinear 3D) plane parallel flows, a family of (nonlinear) parallel pipe flows, as well as flows with uniform injection and suction at the boundary. We also identify a key ingredient in establishing the validity of the Prandtl type theory, i.e., a spectral constraint on the approximate solution to the Navier-Stokes system constructed by combining the inviscid solution and the solution to the Prandtl type system. This is an additional difficulty besides the well-known issue related to the well-posedness of the Prandtl type system. It seems that the main obstruction to the verification of the spectral constraint condition is the possible separation of boundary layers. A common theme of these examples is the inhibition of separation of boundary layers either via suppressing the velocity normal to the boundary or by injection and suction at the boundary so that the spectral constraint can be verified. A meta theorem is then presented which covers all the cases considered here.

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MS30

Vortex Density Models for 3d Superconductors and Superfluids

I will discuss a class of models that describe the distribution of vortex lines in 3d superconductors and superfluids in certain asymptotic limits. These models give rise to associated variational problems that can be viewed as nonlocal, vector-valued generalizations of the classical obstacle problem.

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MS30

Singular Perturbation Models in Phase Transitions for Second Order Materials

In this talk we discuss a variational model proposed in the physics literature to describe the onset of pattern formation in two-component bilayer membranes and amphiphilic monolayers. This leads to the analysis of a Ginzburg-

Landau type energy, precisely,

$$u \mapsto \int_\Omega \left[W(u) - q\,|\nabla u|^2 + \left|\nabla^2 u\right|^2 \right] dx.$$

When the stiffness coefficient $-q$ is negative, one expects curvature instabilities of the membrane and, in turn, these instabilities generate a pattern of domains that differ both in composition and in local curvature. Scaling arguments motivate the study of the family of singular perturbed energies

$$u \mapsto F_\varepsilon(u,\Omega) := \int_\Omega \left[\frac{1}{\varepsilon} W(u) - q\varepsilon |\nabla u|^2 + \varepsilon^3 |\nabla^2 u|^2 \right] dx.$$

Here, the asymptotic behavior of $\{F_\varepsilon\}$ is studied using Γ-convergence techniques. In particular, compactness results and an integral representation of the limit energy are obtained.

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MS30

The Effect of Small Inclusion is Sometimes Not Small

In this talk, we discuss the phenomena of resonance in cloaking for the Helmholtz equation where the effect of small inclusions is sometimes not small and the energy of the solution can go to infinity. Consequently, cloaking is not achieved and the energy of the solution is not finite in some cases. This is unexpected in the literature.

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MS30

Ginzburg-Landau Vortex Dynamics with Pinning and Strong Currents

We study a mixed heat and Schrödinger Ginzburg-Landau evolution equation that is meant to model a superconductor containing impurities and subjected to an applied electric current and electromagnetic field. Such a current is expected to set the vortices in motion, while the pinning term drives them toward minima of the pinning potential and "pins" them there. We derive the limiting dynamics of a finite number of vortices in the limit of a large Ginzburg-Landau parameter, or $\varepsilon \to 0$, when the intensity of the electric current and applied magnetic field on the boundary scale like $|\log \varepsilon|$. We show that the limiting velocity of the vortices is the sum of a Lorentz force, due to the current, and a pinning force. Comparing the two then allows us to identify the "critical depinning current."

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MS31

Numerical Analysis of the Equations of Liquid Crystal Elastomers

We present a finite element analysis of the partial differential equations modeling the static behavior of liquid crystal elastomers. These equations are critical points of the energy that couples the Blandon-Terentjev-Warner elastic free energy of the elastomer with the Landau-deGennes model of liquid crystals. We apply the equations for the compressible elastomer to model phase transitions in actin filament systems.

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MS31

Some Results of the Incompressible Magnetohydrodynamic Flow

Abstract not available at time of publication.

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MS31

Second Order Unconditionally Stable Schemes for Models of Thin Film Epitaxy

Abstract not available at time of publication

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MS31

Blow Up Criterion for Compressible Nematic Liquid Crystal Flows in Dimension Three

We consider the short time strong solution to a simplified hydrodynamic flow modeling the compressible, nematic liquid crystal materials in dimension three. We establish a criterion for possible breakdown of such solutions at finite time in terms of the temporal integral of both the maximum norm of the deformation tensor of velocity gradient and the square of maximum norm of gradient of liquid crystal director field.

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MS31

On the General Ericksen–Leslie System: Parodi's Relation, Wellposedness and Stability

In this paper we investigate the interplay between certain physical relations-namely, Leslie's relations and, more importantly, Parodi's relation-and the wellposedness of the general Ericksen-Leslis system modeling nematic liquid crystal flow. We prove the existence of global classical solutions under assumption of large viscosity and show that Parodi's relation is not a necessary condition in this case. Then we study the near equilibrium case, and reveal that Parodi's relation serves as a stability condition for the liquid crystal system.

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MS32
Traveling Waves in Capillary Fluids

We are interested in compressible, inviscid fluids whose energy depends not only on their density but also on their density gradient. The main purpose of the talk is to investigate the correspondence between traveling waves in Eulerian coordinates and those in Lagrangian coordinates, from both the existence and stability points of view. Under most general assumptions on the energy law, three types of waves will be considered, namely, heteroclinic, homoclinic, and periodic ones.

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MS32
Some Local Well-posedness Results Related to Multi-fluid System

In this talk, we will present some recent mathematical features around multi-fluid models. Such systems may be encountoured for instance to model internal waves, violent aerated flows, oil-and-gas mixtures. Depending on the context, the models used for simulation may greatly differ. However averaged models share the same structure. Here, we address the question whether available mathematical results in the case of a single fluid governed by compressible equations for single flow may be extended to multi-phase models. This is based on joint works with B. Desjardins, J.-M. Ghidaglia, E. Grenier and M. Renardy.

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MS32
Dynamics of Shock Fronts for Some Hyperbolic Systems

Abstract not available at time of publication.

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MS32
Vanishing Viscosity Limit for Isentropic Navier-Stokes Equations

Abstract not available at time of publication.

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MS32
On Global Solutions to the Three-dimensional Magnetohydrodynamics

The three-dimensional compressible and incompressible magnetohydrodynamics (MHD) will be considered. Global weak solution, strong solutions, and incompressible limits will be discussed.

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MS33
Asymptotic Behavior of Fragmentation-drift Equations with Variable Drift Rates

We will describe the asymptotic behavior of solutions to the growth-fragmentation equations with variable drift rates. For this, we give detailed estimates of the steady state and of the solution to the associated dual problem which gives the weight in the conserved quantity of the system. Convergence of solutions to a steady state is investigated through the study of an entropy functional.

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MS33
Entropy Methods for Fragmentation Equations

We show how entropy-entropy dissipation inequalities may be used in the study of the speed of convergence to equilibrium for some equations involving a fragmentation term.

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MS33

Optimization of the Fragmentation for a Prion Proliferation Model

The prion proteins cause transmissible spongiform encephalopathies when they aggregate under their abnormal form. The in vitro amplification of prion proteins is a key point for diagnosis purposes. This problem is modeled by a growth-fragmentation equation with a control parameter in front of the fragmentation operator. The optimization problem is to find the control which maximizes the growth of the quantity of proteins. To this end, we first compare constant controls with periodic controls.

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MS33

L^1 Rate of Convergence to Self-similarity for the Fragmentation Equation

We present a general "factorization" method which makes possible to enlarge the functional space of decay estimates on a semigroup from a "small" Hilbert space to a "larger" Banach space. This method applies to a class of PDE operators writing as a"regularizing" part plus a dissipative part. Next, we explain how we may apply that result to the case of the fragmentation equation and deduce a L^1 rate of convergence to self-similarity for the solutions to the fragmentation equation.

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MS34

Energetic Variational Approaches and Related Issues for Ionic Fluids and Ion Channels

In this talk, we will discuss some specific issues arising from the energetic variational approaches in modeling the ionic fluids and ion channels. We will emphasize on the analytical issues, such as the existence, stability and specific boundary conditions to these problems.

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MS34

Numerical Approximation of the Euler-Poisson-Boltzmann Model in the Quasineutral Limit

This work analyzes various schemes for the Euler-Poisson-Boltzmann (EPB) model of plasma physics. This model consists of the pressureless gas dynamics equations coupled with the Poisson equation and where the Boltzmann relation relates the potential to the electron density. If the quasi-neutral assumption is made, the Poisson equation is replaced by the constraint of zero local charge and the model reduces to the Isothermal Compressible Euler (ICE) model. We compare a numerical strategy based on the EPB model to a strategy using a reformulation (called REPB formulation). The REPB scheme captures the quasi-neutral limit more accurately. This is a joint work with P. Degond, D. Savelief and M-H. Vignal.

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MS34

A Three-Dimensional Model of Electrodiffusion and Osmosis in Cells and Tissues

We introduce a system of PDEs model that describe that seamlessly couples electrodiffusion and osmosis and in the presence of deforming membranes. A salient feature of this model is that it satisfies a natural free energy identity. We discuss how this free energy identity has led to the resolution of a longstanding question on the stability of steady states of pump-leak models of cell volume control.

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MS34

Mean-Filed Description of Ionic Size Effects with Non-Uniform Ionic Sizes: A Numerical Approach

This work begins with a variational formulation of electrostatic free energy that includes ionic size effects and develops numerical methods for the resulting optimization problems. Numerical tests demonstrate that the model and method capture many interesting phenomena, such as the stratification of multivalent counterions near a charged surface, that are not well described by the classical or size-modified Poisson–Boltzmann theory.

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MS35

Wiener Test for the Regularity of Infinity for Elliptic Equations with Measurable Coefficients and its Consequences

We introduce a notion of regularity (or irregularity) of the point at infinity (∞) for the unbounded open set $\Omega \subset R^N$ concerning second order uniformly elliptic equations with bounded and measurable coefficients, according as whether the $\mathcal{A}$- harmonic measure of ∞ is zero (or positive). A necessary and sufficient condition for the existence of a unique bounded solution to the Dirichlet problem in an arbitrary open set of $R^N, N \geq 3$ is established in terms of the Wiener test for the regularity of ∞. It coincides with the Wiener test for the regularity of ∞ in the case of Laplace equation. From the topological point of view, the Wiener test at ∞ presents thinness criteria of sets near ∞ in fine topology. Precisely, the open set is a deleted neigborhood of ∞ in fine topology if and only if ∞ is irregular.

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MS35

On the Inverse Stefan Problem

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 temperature and free boundary. We formulate the inverse Stefan problem as an optimal control problem which takes into account the inaccuracy of the phase transition temperature. We prove well-posedness, Frechet differentiability and convergence of discrete optimal control problems to the original problem in functional and in control.

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MS35

The L^p continuity of the Riesz Transforms Associated with a Subelliptic Operator on a Smooth Manifold

Abstract not available at time of publication.

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MS35

Elliptic Operators and Fractal Singularities

Sub-elliptic and fractal operators, as to their metric and spectral properties, display kind of opposite non-Euclidean behavior. Elliptic operators may develop fractal singularities and in the process geometry undergoes wild changes while spectral measures converge. In our talk we show with examples that non-Euclidean features can be clarified within a common framework from abstract harmonic analysis, potential theory and Dirichlet forms, and the occurrence of fractal singularities can be regulated by asymptotic singular homogenization. This study is done in the perspective of applications to boundary value problems in small domains and large boundaries and is partly supported by NSF Grant DMS-0807840.

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MS35

A Finite Difference Approach to the Infinity Laplace Equation

Abstract not available at time of publication.

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MS36

On Inertially Equivalent Dynamical Systems

In the absence of an inertial manifold, a way of realizing an equivalent finite dimensional dynamical system was suggested in (1). The result of Foias and Olson (2) on the existence of Holder continuous inverse for the Mane's projection has allowed the realization of this program. In (1), this approach was mainly considered for parabolic type PDE's. It was later extended to hyperbolic type of PDE's in (3). In fact, this general approach is adaptable to a variety of dynamical systems that arises from PDE's. Here we will consider its adaptation to a class of hperbolic PDE's with operator coefficients that enjoy exponential attractors. This class was first considered in (4) where existence of an exponential attractor was established using alpha-contractions (see also (5)). This is joint work with V. Kalantarov. References. 1) A. Eden, C. Foias, B. Nicolaenko and R. Temam, Exponential Attractors for Dissipative Evolution Equations, 1994, Paris, Masson Publications. 2) C. Foias, and E.J. Olson, "Finite fractal dimensions and Holder-Lipschitz parametrization", Indiana Univ. Math. J. 45 (1996) 603-616. 3) A. Eden, "Finite Dimensional Dynamics on the Attractors", in Proceedings of the Third International Palestinian Conference in Mathematics and Mathematics Education, editors: S. Elaydi, E.S.Titi, M. Saleh, S.K. Jain and R. Abu-Saris, World Scientific, 90-97, 2002. 4) A. Eden and V. Kalantarov, " Finite dimensional attractors for a class of semilinear wave equations", Turkish Journal of Mathematics, 20 (1996) 3, 425-450. 5) A. Eden, C. Foias and V. Kalantarov " A remark on two constructions of exponential attractors for -contractions", Journal of Dynamics and Differential Equations, 10 (1998) 1, 37-45.

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MS36

Long Time Behavior of Solutions to Flow-Structure Interactions Arising in Modeling of Subsonic Ows of Gas

We shall consider a model of ow-structure interaction which consists of perturbed wave equation coupled with a nonlinear plate. The interaction between two media takes place on the edge of the plate with the dissipation occurring in a small layer near the edge of the plate. We shall consider both subsonic and supersonic case. It is known that in the latter case the static problem looses ellipticity. Questions such as existence and uniqueness of finite energy solutions will be addressed first. The final goal is to determine ge-

ometric conditions for the configuration which would lead to existence of global attractors capturing solutions near the structure (wing of the airplane). The proofs rely on weighted energy methods with suitably constructed geometric multipliers combined with microlocal analysis. This is joint talk with Justin Webster, University of Virginia.

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MS36

A Cahn-Hilliard Model with Dynamic Boundary Conditions

Our aim in this talk is to discuss the dynamical system associated with the Cahn-Hilliard equation with dynamic boundary conditions. Such boundary conditions take into account the interactions with the walls for confined systems. We are in particular interested in a model which accounts for the conservation of mass, both in the bulk and on the walls.

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MS36

Counterexamples in the Attractors Theory

A number of known and new examples/counterexamples related with global/exponential attractors and inertial manifolds will be discussed. These examples indicate the limitations of the theory and show the sharpness of the results previously obtained. In particular, in the class of abstract semilinear equations, we present an example of a global attractor which cannot be embedded in any finitedimensional Lipschitz or log-Lipschitz manifold. In addition, in the class of abstract semilinear damped wave equation, we give an example of a regular (exponential) attractor whose Hausdorff dimension equals two and the fractal (box-counting) dimension is greater than two and is not the same in different Sobolev spaces.

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MS37

Time-like Willmore Surfaces in Minkowski Space

Willmore surfaces X arise as critical points of the so-called Willmore energy $W(X) = \int H^2 dA$ and they satisfy the fourth order Euler-Lagrange equation $\triangle H + 2H(H^2 - K) = 0$. Here, H and K are mean and Gaussian curvature of X and $\triangle$ is the Laplace-Betrami operator. In case of time-like surfaces in Minkowski space $R^{2,1}$, this Laplace-Betrami operator is of hyperbolic type. By replacing fourth order Euler-Lagrange equation by an equivalent second order, quasilinear, hyperbolic system, we prove existence and uniqueness of time-like Willmore surfaces subject to geometric Cauchy initial conditions. The uniqueness part will also be used to deduce symmetry properties of the solution, assuming corresponding symmetry conditions on the initial data.

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MS37

Compactness and Stability Issues for Fourth Order Elliptic PDEs

I will discuss the notion of stability for elliptic PDEs. This notion of stability is rather new and concerns the sets of all solutions of a PDE and of perturbations of it. I will focus on results for second order equations and raise some questions for fourth-order equations.

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MS37

On Equilibria and Stability of the Axisymmetric Surface Diffusion Flow

Surface Diffusion is a geometric evolution law which dictates that the normal velocity on a surface is equal to the surface laplacian acting on the mean curvature. We consider the case of axisymmetric surfaces, with periodic boundary conditions, evolving according to the surface diffusion flow. We discuss well-posedness and stability/instability of cylinders, which are equilibria in this setting.

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MS37

Maximal Time Estimate for Fourth Order Geometric Flows

We consider closed immersed surfaces evolving by a class of fourth order surface diffusion type flows. Our result, similar to earlier results for the Willmore flow and constrained surface diffusion flows gives both a positive lower bound on the maximal existence time and a total curvature bound during this time. This is joint work with Glen Wheeler and Min-Chun Hong.

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MS38

Existence of Ground States for Fourth-order Wave Equations

Focusing on the fourth-order wave equation $u_{tt} + \Delta^2 u + f(u) = 0$, we prove the existence of ground state solutions $u = u(x + ct)$ for an optimal range of speeds $c \in R^n$ and a variety of nonlinearities f.

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MS38

Existence and Stability of Viscous Profiles in a Nonlinear System of Viscoelasticity

We investigate existence and stability of viscoelastic shock profiles for a class of planar models including the incompressible shear case studied by Antman and Malek-Madani. We establish that the resulting equations fall into the class of symmetrizable hyperbolic–parabolic systems, hence spectral stability implies linearized and nonlinear stability with sharp rates of decay. The new contributions are treatment of the compressible case, formulation of a rigorous nonlinear stability theory, including verification of stability of small-amplitude Lax shocks, and the systematic incorporation in our investigations of numerical Evans function computations determining stability of large-amplitude and or nonclassical type shock profiles. This is a joint work with Blake Baker and Kevin Zumbrun.

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MS38

Existence and Regularity for a Coupled Kinetic-hyperbolic Model of Plasma Dynamics

The fundamental description of a collisionless plasma is given by the Vlasov-Maxwell (VM) equations. When relativistic velocity effects are absent in the model, the existence and regularity of classical solutions to this system of nonlinear hyperbolic PDEs is still unknown, even for the lowest dimensional formulation. In this vein, we consider the one-dimensional problem with a coupled transport field equation which displays the identical difficulties as (VM) and present results concerning the regularity and behavior of solutions.

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MS38

Wellposedness for Some Nonlinear Wave Equations

New approaches have been recently developed to study existence of weak and strong solutions for semilinear wave equations. In this talk I will discuss a larger class of equations for which these methods could be implemented. In particular, an emphasis will be placed on the characteristics that are needed in order to ensure the solvability of the problems through these methods. These features include the existence of some conservation law (i.e. the existence of some nonincreasing, energy-type quantity) and a type of finite speed of propagation.

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MS39

Ergodic Properties of the Burgers Equation in the Noncompact Setting

Burgers equation is a basic hydrodynamic model. The ergodic theory of randomly forced Burgers equation is well-developed in the periodic setting, but understanding the ergodic properties of the Burgers equation in unbounded domains is a challenge. In this talk, I will describe the main ergodic component of the dynamics driven by Poissonian noise of finite total intensity.

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MS39

Potential Feedback and Regularization in Complex Fluid Models

Kinetic formulations of complex fluids can provide non-dissipative regularizing mechanisms that have natural physical interpretations. I will describe recent results in which global existence for arbitrary smooth admissible data follows from such regularization mechanisms.

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MS39

Well-Posedness Results for the Stochastic Primitive Equations of the Oceans and Atmosphere

The primitive equations are widely regarded as a fundamental description of geophysical scale fluid flows and forms the core of the most advanced numerical general circulation models (GCMs). This system may be derived from the compressible Navier- Stokes equations with a combination of empirical observation and scale analysis. In view of the wide progress made in computation the need has appeared to better understand and model some of the uncertainties which are contained in these GCMs. In this context stochastic modeling has appeared as one of the major modes in the contemporary evolution of the field. While the mathematical theory for the deterministic primitive equations is now on a firm ground it seems that very little has been done so far on it stochastic counterpart. For this and other nonlinear SPDE's the issue of compactness remains a challenging problem especially for the case of nonlinear multiplicative noise. Moreover, notwithstanding the very recent global existence results in the 3D case, the PEs are technically more involved than the Navier-Stokes equations and thus present novel challenges in the stochastic setting. In this talk we discuss some recent work on the global existence and uniqueness of solutions of the primitive equations in both 2 and 3 spatial dimensions. This talk represents joint work with A. Debussche, R. Temam, and M. Ziane.

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MS39

Stochastic Burgers Equation with Random Initial Conditions

We prove a new existence theorem for solutions of Burgers equation on the unit interval with random initial conditions and driven by affine (additive + linear) noise. Our approach uses Malliavin calculus techniques. The existence theorem provides a dynamic characterization of solutions of the stochastic Burgers equation on its unstable invariant manifolds. Furthermore, as a corollary of the existence theorem, we show that random equilibrium points on the energy space correspond to (possibly non-ergodic) stationary solutions for the stochastic Burgers equation.

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MS39

Burgers Turbulence and Complete Integrability

A remarkable model of stochastic coalescence arises from considering shock statistics in scalar conservation laws with random initial data. While originally rooted in the study of Burgers turbulence, the model has deep connections to statistics, kinetic theory, random matrices, and completely integrable systems. The evolution takes the form of a Lax pair which, in addition to yielding interesting conserved quantities, admits some rather intriguing exact solutions. We discuss several distinct derivations for the evolution equation and properties of the corresponding kinetic system. This is joint work with Govind Menon (Brown University).

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MS40

Dynamics in Phase Field Models for Dilute Mixtures: A Gradient Flow Approach

It is well-known (heuristically) that motion by the Mullins-Sekerka free boundary problem converges to the solutions of the finite-dimensional Lifshitz-Slyozov-Wagner (LSW) system of ODEs in the dilute regime. Alikakos and Fusco have used direct PDE methods to prove examples of this convergence. Under certain assumptions, we prove a similar convergence result with purely energetic arguments. We exploit both the gradient flow structure of the dynamics as well as a Gamma-convergence result of Peletier and myself for the associated energies in the limit of small volume fraction. The two are bridged following the recent approach of Sandier and Serfaty. This is joint work with Nam Le (Columbia) and Mark Peletier (TU Eindhoven).

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MS40

Worm-like States in Pattern Forming Systems

This talk concerns long, narrow two dimensional domains which arise from one dimensional localized patterns. There are a rich set of associated dynamics, such as curve lengthening, buckling, and (infrequently) side-branching. Two examples are discussed. The first is the subcritical Ohta-

Kawasaki energy which describes diblock copolymer mixtures. Rigorous scaling limits of the functional reveal that energy concentrates on lower dimensional sets, specifically curves. The asymptotic energy of the curves can be formally shown to consist of a negative line energy and a small elastic-type correction. The second example is the generic

(variational) Swift-Hohenberg equation. The emergence of worm-like states can be tied to the existence and stability properties of one-dimensional localized patterns which have received considerable attention in recent years. Criteria are derived for the stability of quasi-one dimensional structures, and dynamics are analyzed in the limit of weak bending.

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MS40

Stability of Steady States and Asymptotic Behavior of Mean-field Models for Micro Phase Separation

We study the mean-field models for diblock copolymer melts, describing the evolution of distributions of particle radii obtained by taking the small volume fraction limit of the free boundary problem where micro phase separation results in an ensemble of small balls of one component. In the dilute case, we identify all the steady states and show the convergence of solutions.

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MS40

Population Adaptive Evolution and Concentration Dynamics

Living systems are subject to constant evolution through the three processes of population growth, selection and mutations, a principle established by C. Darwin. In a very simple, general and idealized description, their environment can be considered as a nutrient shared by all the population. This alllows certain individuals, characterized by a 'phenotypical trait', to expand faster because they are better adapted to use the environment. This leads to select the 'fittest trait' in the population (singular point of the system). On the other hand, the new-born individuals undergo small variations of the trait under the effect of genetic mutations. In these circumstances, is it possible to describe the dynamical evolution of the current trait?

We will give a self-contained mathematical model of such dynamics, based on parabolic equations, and show that an asymptotic method allows us to formalize precisely the concepts of monomorphic or polymorphic population. Then, we can describe the evolution of the 'fittest trait' and eventually to compute various forms of branching points which represent the cohabitation of two different populations.

The concepts are based on the asymptotic analysis of the above mentioned parabolic equations once appropriately rescaled. This leads to concentrations of the solutions and the difficulty is to evaluate the weight and position of the moving Dirac masses that desribe the population. We will show that a new type of Hamilton-Jacobi equation, with constraints, naturally describes this asymptotic. Some additional theoretical questions as uniqueness for the limiting H.-J. equation will also be addressed.

This talk is based on collaborations with G. Barles, J. Carrillo, S. Cuadrado, O. Diekmann, M. Gauduchon, S. Genieys, P.-E. Jabin, S. Mirahimmi, S. Mischler and P. E. Souganidis.

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MS40

Results for a Nonlocal Isoperimetric Problem Related to Diblock Copolymers

I will discuss work with Ihsan Topaloglu on a nonlocal isoperimetric problem arising as the Gamma-limit of the Ohta-Kawasaki model for diblock co-polymers. Focus here is on identifying the global minimizer of the problem posed on the two-torus and on the two-sphere in the regime where the nonlocality is sufficiently small.

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MS41

On Dissipation Anomaly and Energy Cascades in 3D Incompressible Flows

We show, using a general setting for the study of energy cascade in physical scales of 3D incompressible flows recently introduced by the authors, that the anomalous dissipation is indeed capable of triggering the cascade which then continues ad infinitum, confirming Onsager's predictions. We also use these settings to present mathematical evidence of dissipation anomaly in 3D turbulent flows.

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MS41

Ill-Posedness for the Magneto-geostrophic Equations

The magneto-geostrophic equation is an active scalar equation with a very singular drift velocity. We have proved that the "critical" equation is globally well-posed. In contrast, the non-diffusive and even a fractionally diffusive version of the equation is ill-posed in the sense of Hadamard. This is joint work wth Vlad Vicol.

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MS41

Local and Global Existence of Smooth Solutions for the Stochastic Euler Equations on a Bounded Domain

We prove the local existence of pathwise solutions for the stochastic Euler equations in a three-dimensional bounded domain, with a general nonlinear multiplicative noise and slip boundary conditions. In the two-dimensional case we obtain the global existence of these solutions with additive or linear-multiplicative noise. Lastly, we show that linear multiplicative noise provides a regularizing effect in the sense that the global existence of solutions occurs with high probability if the initial data is sufficiently small or if the noise coefficient is sufficiently large.

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MS41

The Euler-Arnold Equation of H^1-optimal Transport

Abstract not available at time of publication.

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MS41

Linear Instability for Euler's Equation - Two Classes of Perturbations

In this talk we will consider 2- and 3-dimensional Euler's equation linearized at steady-state solutions and examine the growth of high frequency perturbations in two separate classes: those that preserve circulation and the corresponding factor space. Instability criteria for each type of perturbation will be established in the form of lower bounds for the essential spectral radius of the linear evolution operator restricted to each class.

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MS42

Stability of Planar Shock Fronts for Multi-d Systems of Relaxation Equations

We study stability of multidimensional planar shock profiles of a general hyperbolic relaxation system whose equilibrium model is a system, under the necessary assumption of spectral stability and a standard set of structural conditions that are known to hold for many physical systems. Our main result is to establish the bounds on the Green's function for the linearized equation and obtain nonlinear L^2 asymptotic behavior/sharp decay rate of perturbed weak shock profiles. To establish Green's function bounds, we use the semigroup approach in the low frequency regime, and use the energy method for the high frequency bounds, separately.

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MS42

Stationary Wave to the Symmetric Hyperbolic-parabolic System in Half Space

In this talk, we consider the large-time behavior of solutions to the symmetric hyperbolic-parabolic system in the half space. For this system, we assume that all of characteristics are non-positive. We show the existence and asymptotic stability of the stationary solution (boundary layer solution) under the smallness assumption on the initial perturbation and the strength of the stationary solution. The key to proof is to derive the uniform a priori estimates by using the energy method under the stability condition of Shizuta–Kawashima type. The present talk is based on the joint research with Professor Shinya Nishibata at Tokyo Institute of Technology.

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MS42

Asymptotic Structure of Solutions to the Euler-Poisson Equations Arising in Plasma Physics

The main concern of this talk is to analyze a phenomena that a boundary layer, called a sheath, occurs on the surface of materials with which plasma contacts. For a formation of the sheath, the Bohm criterion in plasma physics requires the ion velocity must be faster than a certain constant. We show that the Bohm criterion is a sufficient condition for the existence and the stability of the stationary solution to the Euler-Poisson equations.

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MS42

Decay Structure of Regularity-loss Type for Symmetric Hyperbolic Systems with Relaxation

In this talk, we consider the initial value problem for symmetric hyperbolic systems with relaxation. When the systems satisfy the Shizuta-Kawashima condition, we can obtain the asymptotic stability result and the explicit rate of convergence. There are, however, some physical models which do not satisfy the Shizuta-Kawashima condition (cf. Timoshenko system, Euler-Maxwell system). Moreover, it had already known that the dissipative structure of these systems is weaker than the standard type. Our purpose of this talk is to construct a new condition which include the Shizuta-Kawashima condition, and to analyze the weak dissipative structure.

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MS43

Pinning by Holes of Multiple Vortices and Homogenization for Ginzburg-Landau Problems

We consider a homogenization problem for magnetic Ginzburg-Landau functional in domains with large number of small holes. For sufficiently strong magnetic field, a large number of vortices is formed and they are pinned by the holes. We establish a scaling relation between sizes of holes and the magnitude of the external magnetic field when pinned vortices are multiple and their homogenized density is described by a hierarchy of obstacle problems. This stands in sharp contrast with homogeneous superconductors, where all vortices are known to be simple. The proof is based on Ã-convergence approach which is applied to a coupled continuum/discrete variational problem: continuum in the induced magnetic field and discrete in the unknown finite (quantized) values of multiplicity of vortices pinned by holes. This is a joint work with V. Rybalko (Kharkov, Ukraine).

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MS43

On the Asymptotic Behavior of Variational Inequalities set in Cylinders

We would like to study the asymptotic behaviour in ℓ of the solution to elliptic variational inequalities set in generalised cylinders of the type $\ell\omega_1 \mathrm{x} \omega_2$ where ω_1, ω_2 are bounded open subsets of $\mathbf{R}^{\mathbf{p}}$, $\mathbf{R}^{\mathbf{n-p}}$ respectively.

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MS43

A Ginzburg-Landau-type Model for Crystalline Lattice

The structure of a Ginzburg-Landau (GL) model originally introduced to model superconductivity can be extended to describe a variety of other physical phenomena that involve ordered systems. The GL theory is particularly useful for understanding the behavior of structural defects - the regions of disorder that appear, e.g., for topological reasons. In my talk, I will discuss a macroscopic level GL-type model that arises in modeling of dislocations in a crystalline solid. The focus will be on establishing a connection between the coarse-grained model and it's atomistic counterpart.

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MS43

Bubbling at the Boundary for Ginzburg-Landau equations

In this talk we analyze Palais Smale sequences for the Ginzburg-Landau equations with semi-stiff boundary conditions and derive existence results for these equations. This is joint work with Leonid Berlyand and P.Mironescu.

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MS44

Level-Set Flow for Capturing Unstable Geodesics on Surfaces

The level-set method has been succesfully applied to interface deformation problems in a variety of settings due to several inherent advantages it has in handling the motions of curves and surfaces. In this talk, we consider the classic problem in geometry of determining the geodesics of a given surface. For this purpose, we introduce a flow involving mean curvature and the Gauss-Bonnet formula for capturing a surface's geodesics, notably the ones that are unstable. We apply the closest-point representation to handle complex surface geometries and the level-set representation to handle complex curve dynamics for the numerical calculation of these geodesics. We then conduct numerical experiments to verify that even unstable geodesics can be accurately found under our approach.

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MS44

A Posteriori Error Estimates for a Surface FEM Based on an Outer Triangulation

In this talk we describe an adaptive surface finite element method in which the surface mesh is obtained essentially by intersecting the continuous surface with an outer volume (bulk) mesh. Reliability and efficiency properties of the estimator are detailed. This is joint work with Maxim Olshanskii of Moscow State University.

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MS44

Application of the Finite Element Exterior Calculus to the Equations of Linear Elasticity

In this talk, we present an overview of how ideas from the finite element exterior calculus and the link between the de Rham complex and various forms of the elasticity complex can be used to obtain stable mixed finite element approximation schemes for the equations of linear elasticity. These include both schemes in which the stress tensor is symmetric and those in which the symmetry condition is only satisfied weakly. In recent years, a number of new methods have been proposed and analyzed by the authors and other researchers. The emphasis will be on the common framework used to develop these methods.

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MS44

Multisymplectic Hamilton–Jacobi Theory and their Applications to Geometric Integration of Lagrangian Field Theories

We present a derivation of the De Donder–Weyl Hamilton–Jacobi theory by considering a multisymplectic analogue of Jacobi's solution. This is given by the action integral over a region of space-time, for a section of the configuration bundle which satisfies the Euler–Lagrange equations with prescribed fiber boundary conditions. This plays the role of the exact discrete Lagrangian in discrete Lagrangian mechanics, and can be viewed as a generating function of a multisymplectic relation. We demonstrate how this naturally leads to internal boundary conditions that allow piecewise solutions of the Euler–Lagrange field equations to be patched together in a multisymplectic fashion. In turn, this yields a framework for constructing geometric integration algorithms for Lagrangian field theories that can be implemented in a parallel and distributed fashion.

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MS45

Incompressible Fluid Coupled with Nonlinear Elasticity

The problem under consideration is the nonlinear coupling of Navier-Stokes and elasticity. I will present a completely new linearization, derived in view of the stability analysis. The linearization reveals the presence of the curvature on the common interface, which demonstrates that the free boundary plays a key role in the analysis of the coupled system and its influence can not be neglected.

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MS45

Moving-boundary Problems of Mixed Type Arising in Modeling Blood Flow

Abstract not avaiable at time of publication.

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MS45

Local Well-posedness for a Fluid-structure Interaction Model

In the talk we address a system of PDEs describing an interaction between an incompressible fluid and an elastic body. The fluid motion is modeled by the Navier-Stokes equations while an elastic body evolves according to an elasticity equation. On the common boundary, the velocities and stresses are matched. We discuss available results on local well-posedness and prove a new existence and uniqueness result with the initial fluid velocity and the initial velocity of the structure belonging to low regularity spaces.

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MS45

Well-posedness of Nonlinear Fluid-structure Interaction Problems with Moving Interfaces

We will discuss existence theorems for nonlinear fluid-structure interaction problems with moving material interfaces. We consider the motion a 3-D nonlinear elastic solid inside of a 3-D Navier-Stokes fluid or a 3-D Navier-Stokes fluid moving inside of a 2-D nonlinear elastic shell. The shell can be either a biofluid shell or solid shell of Koiter type. Joint work with Arthur Cheng and Daniel Coutand.

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MS45

Variational Solution for Mhd Problem

We give a variational solution for the following MHD problem. Find

$$(\zeta = \zeta^2, V) \in L^1(0,1,H^r(D)) \times L^1(0,1,L^1(D,R^3))$$

Such that

$$\frac{\partial}{\partial t}(\zeta\, V) + D(\zeta\, V).V + \nabla p = E \times curl\, V \;+ \mathcal{H}_r\, \nabla\zeta$$

$$divV = 0, \;\; \frac{\partial}{\partial t}\zeta + \nabla\zeta.V = 0$$

Where $0 < r < 1/2$ and $\mathcal{H}_r$ is the new Sobolev curvature introduced in [1] and based of the property of bounded perimeter sets whose characteristic function $\zeta \in H^r(D)$, $\forall r$, $0 < r < 1/2$. This new mean curvature turns to be the shape gradient of the shape differentiable sobolev perimeter. [1] Shape Morphic Metric, Operator Theory: Advances and Applications, Vol. 216, 343367, 2011 Springer Basel AG

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MS46

Global solutions to the Navier-Stokes-Vlasov-Fokker-Planck equations

In this talk, we consider the particle-spray model in combustion theory. The model is described by the Navier-Stokes equations and the coupled Fokker-Planck equation. At first, we consider the global-in-time existence of the weak solution for this model in two or three dimensions. And then we consider two dimensional Navier-Stokes-Vlasov-Fokker-Planck equations. For the equations, we can show that the global-in-time existence of the smooth solution. Also we consider three dimensional Vlasov-Stokes equations. This is the joint work with Myeongju Chae and Kyungkeun Kang.

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MS46

Boundary Regularity of Degenerate Elliptic Equations without Boundary Conditions

In this talk, we discuss a class of degenerate elliptic equations with a unique smooth solution (in any suitably smooth domain) without prescription of boundary condition. (In fact the equation degenerates on the entire boundary.) The results are similar to those for certain ordinary differential equations with regular singular points but the method of proof is very different.

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MS46

Thermosolutal Convection at Infinite Prandtl Number with or without Rotation: Bifurcation and Stability in Physical Space

We examine the nature of the thermosolutal convection with or without rotation in the infinite Prandtl number regime, which is applicable to magma chambers. The onset of bifurcation and the structure of the bifurcated solutions in this double diffusion problem are analyzed. The stress-free boundary condition is imposed at the top and bottom plates confining the fluid. For the rotation free case, 2-dimensional Boussinesq equations are considered and we prove that there are bifurcating solutions from the basic solution and that the bifurcated solutions consist of only one cycle of steady state solutions that are homeomorphic to S^1. By thoroughly investigating the structure and transitions of the solutions of the thermosolutal convection problem in physical space, we confirm that the bifurcated solutions are indeed structurally stable. In the presence of rotation, we consider 3-dimensional Boussinesq equations and we can get similar results as of the rotation free case. We also see how intensively the rotation inhibits the onset of convective motion. In turn, this will corroborate and justify the suggested results with the physical findings about the presence of roll structure.

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MS46

Semi-hyperbolic Patches of Two Dimensional Riemann Problems

We study semi-hyperbolic patches of two dimensional Riemann problems. These patches are essential parts in understanding some configurations formed by the interaction of elementary waves like the interaction of 2 forward rarefaction waves and 2 backward rarefaction waves.

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MS46

The Sonic Line As a Free Boundary

We consider the steady transonic small disturbance equations on a domain and with data that lead to a solution that depends on a single variable. After writing down the solution, we show that it can also be found by using a hodograph transformation followed by a partial Fourier transform. This motivates considering perturbed problems that can be solved with the same technique. We identify a class of such problems.

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MS47

Some New Results for Reaction Cross-diffusion Equations

We introduce new results based on entropy methods and duality methods for systems of PDEs involving cross diffusion and reaction terms. Those equations model situations occuring in population dynamics when the diffusion rate of one species depends on the concentration of another species. The existence theory and the approximation by standard reaction-diffusion equations are revisited.

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MS47

P-gp Transfer and Acquired Multi-drug Resistance in Tumors Cells

Multi-Drug resistance for cancer cells as been a serious issue since several decades. In the past, many models have been proposed to describe this problem. These models use a discrete structured for the cancer cell population, and they may include some class of resistant, non resistant, and acquired resistant cells. Recently, this problem has received a more detailed biological description, and it turns out that the resistance to treatments is due in 40% of cancers to a protein called P-glycoprotein (P-gp). Moreover some new biological experiments show that transfers can occur by the mean of Tunneling nanoTubes built in between cells (direct transfers). But transfers can also occur through microparticles (containing P-pg) released by over expressing cells into the liquid surrounding these cells. These microparticles can then diffuses and can be recaptured by the cells (indirect transfers). This transfers turn to be responsible for the acquired resistance of sensitive cells. The goal of this talk is to introduce this problem, and to present a cell population dynamic model with continuous P-gp structure.

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MS47

Evolution of Species Trait Through Resource Competition

We study a chemostat-type model where species consume resource that are constantly supplied. Continuous traits in both consumer species and resource are incorporated. Consumers utilize resource whose trait values are similar with their own. This model is more mechanistic than the so-called direct-competition model, studied widely in the literature, because the competitive interaction of species occurs not directly but through competition for resource. We prove that self-organized generation of distinct species occurs. We also prove global convergence to the evolutionarily stable distribution.

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MS48

Well-posedness of the Cauchy Problem for a Class of Multidimensional Nonlinear Stochastic Balance Laws

We are interested in the well-posedness and continuous dependence for a class of multidimensional nonlinear stochastic balance laws. The vanishing viscosity method is employed to establish the existence of entropy solutions. One of our main observations is the uniform BV bounds in the space-variables for stochastic viscous solutions. Based on the the unform BV bounds, we establish the equicontinuity of the viscous solutions in the time-variable, uniform in the viscosity coefficient. With these uniform estimates, we then establish the existence theory of stochastic entropy solutions in BV as the vanishing viscosity limits, when the initial data functions are in BV . We further establish the continuous dependence of BV stochastic entropy solutions on the flux functions and the the coefficient functions in the random source terms. This leads to the well-posedness theory in L^p for the class of multidimensional nonlinear stochastic balance laws. Various further generalizations of the results are also discussed.

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MS48

Well-posedness of the 3-D Compressible Euler Equations with Moving Physical Vacuum Boundary

We establish the well-posedness of the 3-D compressible Euler equations with "physical" vacuum boundary, wherein the sound speed must vanish as the square-root of the distance function to the vacuum. This is a degenerate and characteristic hyperbolic moving free-boundary system of multi-D conservation laws, wherein the regularity of the geometry of the free-surface is coupled to regularity of the velocity and density at leading order. This is joint work with D. Coutand.

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MS48

On the Structure of Solutions of Nonlinear Hyperbolic Systems of Conservation Laws

In this talk we show that Liouville theorems for systems of conservation laws yield the existence of strong traces on hyperplanes of bounded entropy solutions for the one dimensional isentropic Euler equations.

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MS48

Some Mixed Type Problems in Gas Dynamics and Geometry

Some mixed elliptic-hyperbolic problems arising in gas dynamics and differential geometry will be considered. In particular, the mixed type problems of the transonic flow past an obstacle and the isometric embedding will be discussed. Our recent results including the connection of the two problems will be presented. The talk is based on the joint works with Gui-Qiang Chen and Marshall Slemrod.

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MS49

Wave Operators and Applications

Abstract not available at time of publication.

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MS49

The Radial Defocusing Energy-supercritical Cubic Nonlinear Wave Equation in R^{1+5}

In this talk, we will discuss the energy-supercritical defocusing cubic nonlinear wave equation in dimension d=5 for radially symmetric initial data. We prove that an a priori bound in the critical homogeneous Sobolev space implies global well-posedness and scattering. The main tool that we use is a frequency localized version of the classical Morawetz inequality, inspired by recent developments in the study of the mass and energy critical nonlinear Schrödinger equation.

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MS49

Global Smoothing for the Periodic KdV Evolution

The KdV equation with periodic boundary conditions is considered. It is shown that for H^s initial data, $s > -1/2$, and for $a < \min(2s + 1, 1)$, the diffference of the nonlinear and linear evolutions is in H^{s+a} for all times, with at most polynomially growing norm. This and a theorem of Oskolkov for the Airy evolution imply that for continuous and bounded variation initial data, the solution is a continuous function of space and time.

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MS49

Recent Results on the Gross-Pitaevskii Hierarchy

The Gross-Pitaevskii (GP) hierarchy is an infinite system of coupled linear non-homogeneous PDEs, which appear in the derivation of the nonlinear Schrödinger equation (NLS). Inspired by the PDE techniques that have turned out to be useful on the level of the NLS, we realized that, in some instances we can introduce analogous techniques at the level of the GP. In this talk we will discuss some of those techniques which we use to study well-posedness for GP hierarchies.

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MS49

Long Time Dynamics for Forced and Weakly Damped KdV on the Torus

We prove that the L^2 solution for the forced and weakly damped KdV decomposes into a linear part which decays to zero as time goes to infinity and a nonlinear part which always belongs to a smoother space. This gives a new proof for the existence of a smooth global attractor and provides quantitative information on the size of the attracting set. We also prove that higher order Sobolev norms are bounded for all positive times.

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MS50

Fluctuation Theories Beyond Homogenization in Random Media

The theory of homogenization is well known for many elliptic partial differential equations. The theory of random fluctuations is much less understood. This talk will review some recent results obtained on the random fluctuations (random corrector) of sufficiently simple elliptic equations and on some applications of such theoretical results.

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MS50

Adhesion of Heterogeneous Media

This talk will describe a rich class of free-boundary problems motivated by the simple phenomenon of peeling a tape. Specifically, we consider the homogenization of these free boundary problems, and show that the effective adhesive strength of a heterogeneous system can be dramatically different from that of a homogeneous system.

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MS50

From Homogenization to Averaging in Cellular Flows

We consider an elliptic eigenvalue problem in the presence a fast cellular flow in a two-dimensional domain. It is well known that when the amplitude, A, is fixed, and the number of cells, L^2, increases to infinity, the problem 'homogenizes' – that is, can be approximated by the solution of an effective (homogeneous) problem. On the other hand, if the number of cells, L^2, is fixed and the amplitude A increases to infinity, the solution "averages'. In this case, the solution equilibrates along stream lines, and it's behaviour across stream lines is given by an averaged equation. In this talk we study what happens if we simultaneously send both the amplitude A, and the number of cells L^2 to infinity. It turns out that if $A \ll L^4$, the problem homogenizes, and if $A \gg L^4$, the problem averages. The transition at $A \approx L^4$ can quickly predicted by matching the effective diffusivity of the homogenized problem, to that of the averaged problem. However a rigorous proof is much harder, in part because the effective diffusion matrix is unbounded. This is joint work with T. Komorowski, A. Novikov and L. Ryzhik.

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MS50

Some Properties of Large Deviations for Mean Field Models of Phase Transitions

I will introduce and discuss some mean field models and then show that a class of large deviation probabilities can be calculated explicitly in the limit of weak bistability. This means that the system is close to a phase transition, and then the small probability of its occurance can be calculated approximately and its dependence on the parameters of the problem can be seen explicitly.

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MS51

Interior Regularity for a Minimal Principal Curvature Operator

In this talk I will present a proof of the continuity of solutions to certain degenerate elliptic operators, connected to the curvature of the level sets (of the solution). An example of such an operator in 2 dimensions is $\Delta - \Delta_\infty$.

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MS51

Contact Solutions for Fully Nonlinear Systems and the Aronsson System of PDEs

We will present some rudiments of a recently proposed theory of non-differentiable solutions which applies to fully nonlinear systems of PDEs and extends the theory of Viscosity Solutions of Crandall-Ishii-Lions to the general vector case. The main contribution is the discovery of an Extremality notion for vector functions which extends the scalar extrema and is characterized by a Maximum Principle type calculus applying to vector functions. This leads to a PDE theory within which numerous non-differentiable solutions of systems like the Infinity-Laplacian and the general Aronsson system can be rigorously interpreted, while, most importantly, the theory supports flexibility under limit operations, preserving the working philosophy and the main features of the scalar viscosity counterpart. In the context of this new framework, we will discuss some recent applications to the Aronsson system of PDEs and Calculus of Variations in L^∞.

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MS51

The p-Laplacian on Graphs

We study a version of the p-Laplace operator in non-divergence from on graphs which are the discrete version of the p-harmonius functions that appear as value functions of tug-of-war games with noise. This is joint work with Alexander Sviridov and Adam Oberman.

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MS51

Vector-valued Optimal Lipschitz Extensions

I will discuss joint work with Scott Sheffield extending the theory of absolutely minimizing Lipschitz extensions to the vector-valued case.

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MS52

Levy Processes and Fourier Multipliers

We investigate the L^p-norms of certain Fourier multipliers which arise from *Lévy* processes. These operators have connections to several classical singular integrals in harmonic analysis.

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MS52

Harnack Inequalities and Regularity Estimates for Discontinuous Processes

The aim of this talk to present some Harnack inequalities and regularity estimates for Harmonic function associated with operators of discontinuous processes. These operators are in general integro-diffferential operators. Our approach will be mainly probabilistic

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MS52

The Harnack Inequality and Littlewood-Paley Functions for Symmetric Stable Processes

In recent years, there has been an increasing interest in jump processes and their applications. In this talk, we consider α-harmonic functions which are defined with respect to the product of a one dimensional Brownian motion and a d-dimensional symmetric stable process. We discuss Harnack inequality from a probabilistic approach and then we show some properties and regularity of α-harmonic functions. In the last part, we talk about Littlewood-Paley functions obtained by means of the harmonic extension of a function on R^d which is considered as the boundary of the half-space $R^d \times R^+$.

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MS52

Harnack's Inequality: A New Formulation and Applications

We present a formulation of Harnack's inequality which is applicable to local and nonlocal operators at the same time. We show that this version of Harnack's inequality implies regularity estimates for solutions to several integrodifferential operators. We apply the method to some nonlocal symmetric Dirichlet forms and to generators of jump processes. We discuss how this approach extends known results significantly. The talk is based on three works: [K. 2010], [K.-Mimica 2011] and [Dyda-K. 2011]

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MS53

An Active Scalar Equation for the Geodynamo

We discuss an active scalar equation proposed by Moffatt as a model for the geodynamo. We prove that this equation is globally well posed. We illustrate strong dynamo action by proving that a particular example is nonlinearly unstable.

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MS53

An Alternative Approach to Regularity for the Navier-Stokes Equations in Critical Spaces

We use the dispersive method of"critical elements" established by Kenig and Merle to give an alternative proof of a well-known Navier-Stokes regularity criterion due to Escauriaza, Seregin and Sverak, namely that 3-d solutions whose spatial L^3-norm remain bounded in time cannot develop a singularity. The key tool is a decomposition into "profiles" of bounded sequences in critical spaces (e.g., L^3). As a byproduct, we also generalize a recent result of Rusin and Sverak on "minimal blow-up data" for Navier-Stokes.

We will also discuss generalizations of the Escauriaza-Seregin-Sverak criterion. This is joint work with Isabelle Gallagher and Fabrice Planchon.

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MS53

Asymptotic Behaviour of Infinite Energy Solutions to Navier-Stokes Equations

We study the asymptotic behaviour of solutions to the $2D$ Navier-Stokes equations with initial data in some "infinite energy spaces", namely some homogeneous scale-invariant Besov spaces. We use the results obtained to understand the long time behaviour of solutions with vortex-sheet-like initial data. This is joint work with Clayton Bjorland (Univ. of Texas - Austin).

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MS53

Asymptotic Stability of Landau Solutions to Navier–Stokes System

It is known that the three dimensional Navier-Stokes system for an incompressible fluid in the whole space has a one parameter family of explicit stationary solutions, which are axisymmetric and homogeneous of degree -1. We show that these solutions are asymptotically stable under any L^2-perturbation.

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MS53

Regularity Results for the Prandtl-Reuss Law

We consider regularity aspects for solutions to variational inequalities which describe the deformations of elastic plastic bodies, thereby starting with the Prandtl-Reuss problem. Using difference quotients and Fourier analysis together with canonical assumptions for the data we show fractional time-differentiability of the stress velocity. With suitable modifications the method can also applied to the cases of isotropic or kinematic hardening.

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MS54

Pseudospectral Reduction of Incompressible Two-Dimensional Turbulence.

Spectral reduction was originally formulated entirely in the wavenumber domain as a bin-averaged wavenumber convolution in which bins of modes interact with enhanced coupling coefficients. A Liouville theorem leads to inviscid equipartition solutions when each bin contain the same number of modes. We describe a pseudospectral implementation of spectral reduction which enjoys the efficiency of the fast Fourier transform. The model compares well with full pseudospectral simulations of the two-dimensional forced-dissipative energy and enstrophy cascades.

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MS54

Approximate Deconvolution Large Eddy Simulation of a Barotropic Ocean Circulation Model

This talk introduces a new large eddy simulation closure modeling strategy for two-dimensional turbulent geophysical flows. This closure modeling approach utilizes approximate deconvolution, which is based solely on mathematical approximations and does not employ phenomenological arguments, such as the concept of energy cascade. The new approximate deconvolution model is tested in the numerical simulation of the wind-driven circulation in a shallow ocean basin, a standard prototype of more realistic ocean dynamics. The model employs the barotropic vorticity equation driven by a symmetric double-gyre wind forcing, which yields a four-gyre circulation in the time mean. The approximate deconvolution model yields the correct four-gyre circulation structure predicted by a direct numerical simulation, on a much coarser mesh and at a fraction of the computational cost. This first step in the numerical assessment of the new model shows that approximate deconvolution represents a promising approach for the large eddy simulation of more realistic turbulent geophysical flows.

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MS54

Aspect-ratio Effects in Boussinesq Flows with Rotation and Stratification

I will present numerical evidence from high-resolution simulations performed on Blue Gene/Petascale resources using

32K cores or more, which reveal novel small-scale (sub-forcing scale) features in small aspect ratio rotating and stratified Boussinesq flows. I will discuss our attempts to disentangle the effects of small aspect-ratio from those of rotation and stratification.

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MS54

The Baroclinic Instability and Turbulence Parameterizations in Ocean Models

The baroclinic instability, where the potential energy of tilted isopycnals in the ocean is converted to kinetic energy, is challenging for ocean models because the eddies must be resolved to properly capture this process. We present a channel test problem were the isopycnals remain tilted at low resolution, while at higher resolution eddies form and isopycnals flatten out. It is the job of parameterizations to capture such important physical effects at lower resolution. How well do various ocean model parameterizations perform in this baroclinic instability test? Simulations using the Lagrangian-averaged Navier Stokes-alpha (LANS-alpha) turbulence parameterization in the POP ocean model resemble higher resolution simulations of standard POP in statistics like kinetic energy, eddy kinetic energy, and potential temperature fields. The LANS-alpha model accomplishes this improvement through an additional nonlinear term and a smoothed advecting velocity. I also show comparisons between the LANS-alpha model and Gent-McWilliams (GM) model. The alpha model is shown to make superior predictions of eddy kinetic energy equivalent to that produced at twice the resolution with no model, while the GM model excels at description of the tracers but suppresses eddy kinetic energy.

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MS54

Separation of Scales in Strongly Rotating Flows with Weak Stratification

Motivated by gaining fundamental understanding of ocean dynamics at high latitudes my collaborators and I have derived new equations, based on the method of multiple scales presented in Embid and Majda (1996,1998) that address the scale separation between slow- and fast-time dynamics in the limit of fast rotation and weak stratification. The slow dynamics describes a regime we call *Taylor-Proudman* flows. We also show numerical simulations that support the theory.

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MS55

Particle Interaction Models of Biological Aggregation

Animal groups often form striking aggregation patterns. Examples include from schools of fish to locust swarms, to patterns in bacterial cultures. In this talk, we discuss a very simple model of swarming based on pairwise particle interactions with short-range attraction and long-range repulsion, which can lead to very complex and intriguing patterns in two or three dimensions. Depending on the relative strengths of attraction and repulsion, a multitude of various patterns are observed, from nearly-constant density swarms to annular solutions, to complex N-fold symmetry patterns. We show that many of these patterns can be understood as a result of a bifurcation of a ring-type pattern. Turing-type analysis of a ring reveals a wealth of possible instabilities which often lead to complicated and beautiful patterns. Using weakly nonlinear analysis, we also classify two-ring, annular and triangular patterns which arise when the ring becomes unstable.

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MS55

Steady States of Nonlocal Interaction Equations with Repulsive-attractive Potential

We consider radially symmetric solutions of nonlocal interaction equations with repulsive attractive potential. We prove various results about convergence of solutions toward steady state. This is a joint work with Balague, Carrillo and Raoul.

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MS55

Nonlocal Aggregation Equations and Concentration Phenomena

Nonlocal aggregation equation appear in various fields of physics and biology. In many situations, the interaction potential presents a singularity at the origin. This singularity, which can be either attractive or repulsive, has a significant impact on the qualitative properties of solutions. In this talk, I will present a qualitative study of those qualitative properties in one and in several dimensions (although most questions remain open in the latter case). This work has been done in collaboration with Klemens Fellne, Daniel

Balague, Jose Carrillo and Thomas Laurent.

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MS55
Interfacial Behavior in Biological Aggregation

Individuals, described by the model of biological aggregation studied by Topaz, Bertozzi and Lewis, experience long range attraction, but also avoid overcrowding due to a short-range repulsion. In the continuum model the attraction is described via a nonlocal operator, while the repulsion is modeled by a differential operator. We show that the density profile develops interfaces between a near-constant-density aggregate state and the empty space. The interfaces evolve under surface-tension-like "forces'. More precisely, we demonstrate that the sharp-interface limit for the interfacial motion is the Hele-Shaw flow.

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MS55
Stability and the Inverse Statistical Mechanics Problem for Aggregating Particles

Pairwise particle interactions arise in diverse physical systems ranging from insect swarms and bacterial distributions, to self-assembly of nanoparticles. In the presence long-range attraction and short-range repulsion, such systems may exhibit rich patterns in there bound states. In this talk we present a theory to classify the morphology of various patterns in N dimensions from a given confining potential. We also present a method to solve the inverse statistical mechanics problem: Given an observed pattern, can we construct a confining interaction potential which exhibits that pattern.

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MS56
Turning Waves and Breakdown for Muskat

We consider the dynamics of an interface given by two incompressible fluids with different densities satisfying Darcy' s law. This scenario is known as the Muskat problem. In this talk we show the existence of initial data that evolves from a stable regime to an unstable regime in finite time for which the Rayleigh-Taylor changes sign and the solution breaks down. Joint work with A. Castro, C.Fefferman, F.Gancedo and M. Lpez-Fernndez.

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MS56
Splash Singularity for Water Waves

We exhibit smooth initial data for the 2D water wave equation, for which we prove that smoothness of the interface breaks down in finite time. Joint work with A. Castro, D. Cordoba, F.Gancedo and J. Gomez.

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MS56
The Spine of an SQG Almost-sharp Front

Consider solutions to the surface quasi-geostrophic equation (SQG) that take the values 1 and -1 outside a delta-neighborhood of an evolving curve – they are called the almost sharp fronts for the SQG. Cordoba-Fefferman-Rodrigo (2004) showed that any curve that describes an almost sharp front (up to an error of order delta) satisfies an evolution equation up to an error of order $deltaLog|delta|$. I will describe recent work with Fefferman and Rodrigo on improving the error to $delta-squared-log|delta|$ by introducing a special class of curves (which we call the spines).

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MS56
Knots and Links in Fluid Mechanics

In 1965 V.I. Arnold classified the steady solutions of the Euler equation, implying in particular that the topological structure of the stream (or vortex) lines of a fluid is quite restricted except for the so called Beltrami fields. Arnold's work and the phenomena of frozeness of vorticity and magnetic relaxation gave rise to the conjecture in topological hydrodynamics that any knot and link can be realized as a set of stream (or vortex) lines of a steady solution of the Euler equation. The importance of this conjecture is that it tests the topological and geometrical complexity of steady fluid flows. The goal of this talk is to review the strategy which has recently led to the proof of this conjecture for Beltrami fields in $\mathbf{R}^3$ (to appear in Ann. of Math. 2011), as well as some interesting applications as the solution to the Etnyre-Ghrist problem: there exists a steady solution of the Euler equation containing all knot and link types.

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MS57

Liouville-Type Theorems for a Class of Degenerate and Singular Parabolic Equations

Relying on recent results on Harnack inequalities for equations of p-Laplacian type, and porous medium type, we prove Liouville-type estimates for solutions to these equations, both in the degenerate ($p > 2$, $m > 1$), and in the singular ($1 < p < 2$, $0 < m < 1$) range.

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MS57

New Class of Constitutive Models Giving Rise to Challenges to PDE

The implicit constitutive theory expands the repertoir of continuum models that can be used to describe complicated response of complex materials, yet keeping the number of involved quantities and boundary conditions unchanged. The framework includes the classical explicit models where the thermodynamical fluxes such as the Cauchy stress and the heat flux are nonlinear functions of thermodynamical affinities. More importantly, the framework includes a new class of explicit models in which the thermodynamical affinities are nonlinear functions of thermodynamical fluxes.We in particuar focus on models related to flows through porous media. Some preliminary mathematical results concerning generalized Darcy-Forchheimer equations with pressure dependent coefficient will be also presented

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MS57

Well-Posedness Theory for an Aggregation Equations and Patlak-Keller-Segel Models with Degenerate Diffusion

Recently, there has been much interest in modeling the competition between a species desire to aggregate and the desire for personal space, referred to as dispersal. Two mathematical systems which model this competition are aggregation diffusion equations and Patlak-Keller Segel models, originally developed to model chemotaxis. Although the research of these two models have evolved separately they model the same phenomena. Classically, in the PKS equation, aggregation is modeled via convolution with the Newtonian or Bessel potential. On the other hand, the aggregation equation has been studied with more regular kernels. Our work focuses on unifying and extending the well-posedness theory of these equations. In particular, we study the well-posedness of an aggregation equation with degenerate diffusion, to model over-crowding effects, where the aggregation is modeled via the convolution with potentials as singular as the Newtonian potential. We generalize the notion of criticality seen in the PKS model with power-law diffusion and we observe a similar critical mass phenomenon. In this talk I will discuss discuss the local and global well-posedness results from this work with an emphasis on the continuation theorem which connects the local and global theory.

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MS57

Mixed Formulations of Coupled Systems of Mechanics and Diffusion

Nonlinear coupled Darcy, Stokes, and Biot systems describe flow through deformable porous media and internal fractures or adjacent regions of free fluid. Such systems will be developed as examples of nonlinear degenerate evolution equations in mixed formulation, and their dynamics is determined by nonlinear semigroups.

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MS57

Well-posedness and Long Time Behavior of the Hele-Shaw-Cahn-Hilliard System

We discuss the well-posedness and long time beahvior of the Hele-Shaw-Cahn-Hilliard system modeling binary fluid flow in porous media with arbitrary viscosity contrast but matched density between the components. Well-posedness that is global in time in the two dimensional case and local in time in the three dimensional case will be presented. Several blow-up criterions in the three dimensional case are provided as well. Long time behavior in terms of eventual regularity and convergence to steady states will be presented. Formal link to the sharp interface problem will be discussed as well.

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MS58

On Minimizers of the Doubly-Constrained Helfrich Functional

Since the pioneering paper of Helfrich in 1973, variational formulations involving curvature-dependent functionals have proven useful for shape analysis of biomembranes. We present a existence result for doubly-constrained global minimizers of a functional containing a spontaneous (preferred) curvature. The functional is minimized over axisymmetric surfaces with fixed area and enclosing a fixed volume. This is joint work with Marco Veneroni (McGill).

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MS58

Epitaxially Strained Thin Films: Regularity of Quantum Dots and Motion by Anisotropic Surface Diffusion

Short time existence, uniqueness, and regularity for a surface diffusion evolution equation with curvature regularization are proved in the context of epitaxially strained two-dimensional films. This is achieved by using the H^{-1}-gradient flow structure of the evolution law, via De Giorgi's minimizing movements. This seems to be the first short time existence result for a surface diffusion type geometric evolution equation in the presence of elasticity.

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MS58

Thin Films for Ginzburg Landau in the London Limit

I will present recent results in collaboration with Stan Alama and Lia Bronsard on thin film London limits of the Ginzburg–Landau model for a superconductor in an applied magnetic field oriented obliquely to the film surface. We obtain Γ–convergence results for the first and second critical fields under particular asymptotic ratios between the magnitude of the parallel applied magnetic field and the thickness of the film. For the first critical field, we study the optimal density of vortices via an obstacle problem for some examples to illustrate how the geometry of the domain will affect the position of vortices.

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MS58

Multiscale Gamma Convergence for Point Interactions in 2D

We derive energies governing the blow-up limits of N coulombian charges interacting at the scale $\sqrt{1/N}$, with consequences for superconducting vortices and/or random matrices.

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MS59

Analysis of Nematic Liquid Crystals with Disclination Lines

We investigate the structure of nematic liquid crystal thin films described by the Landau-de Gennes tensor-valued parameter with Dirichlet boundary conditions of nonzero degree. We prove that as the elasticity constant goes to zero, a limiting uniaxial texture forms with disclination lines corresponding to a finite number of defects, all of degree $\frac{1}{2}$ or all of degree $-\frac{1}{2}$. We also analyze the limiting behavior of the defects.

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MS59

Defects in Thin Smectic Liquid Crystal Films

We analyze a model for the elastic energy of planer c-director patterns in a smectic film. Because of boundary conditions and polar fields topological defects form in these patterns. We use a Ginzburg Landau model that allows the director field to have variable length and to vanish at the defect cores. We prove that if the model's G-L parameter is small then low energy states develop degree (±) one defects that tend to a minimal energy configuration with a limiting far-field texture. Our main contribution is that we are able to treat the case of unequal splay and bend elasticity constants. Earlier analytic work for the G-L functional had been limited to the equal constant case.

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MS59

Well-posedness for the 3-D Compressible MHD Equations with Moving Vacuum Boundary

We establish well-posedness for the 3-D compressible MHD equations with moving physical vacuum boundary. The physical vacuum boundary permits the plasma to accelerate, and requires the sound speed and the magnetic field to degenerate like the square-root of the distance function to the moving boundary. As such, the MHD equations form a multi-D system of conservation laws which are both characteristic and degenerate. This is joint work with Joseph Grimm.

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MS59

Numerical Approximation of the Ericksen Leslie Equations

The Ericksen Leslie equations model the motion of nematic liquid crytaline fluids. The equations comprise the linear and angular momentum equations with non-convex constraints on the kinematic variables. These equations possess a Hamiltonian structure which reveals the subtle coupling of the two equations, and a delicate balance between inertia, transport, and dissipation. While a complete theory for the full nonlinear system is not yet available, many interesting sub-cases have been analyzed. This talk will focus on the development and analysis of numerical schemes which inherit the Hamiltonian structure, and hence stability, of the continuous problem. In certain situations compactness properties of the discrete solutions can be established which guarantee convergence of schemes.

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MS59

Specific Tensorial Features in the Modelling of Nematic Liquid Crystals

Nematic liquid crystals are modelled mathematically using either: unit-length vectors in the Oseen-Frank theory (2 degrees of freedom), scalars and unit-length vectors in Ericksen theory (3 degrees of freedom) or symmetric and traceless 3x3 matrices in Landau-de Gennes theory (5 degrees of freedom). We will look into specific features of nematics that require a tensorial description, with an emphasis on the interpretation of defects in various theories.

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MS60

Lagrangian Solutions of Semigeostrophic System

Semigeostrophic system is a model of large-scale atmospheric/ocean flows. I will discuss some results on existence and properties of weak Lagrangian solutions in physical space. Open problems will be also discussed.

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MS60

Title Not Available at Time of Publication

Abstract not available at time of publication.

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MS60

On a Chemotaxis Model

We investigate local/global existence, blowup criterion and long time behavior of classical solutions for a hyperbolic-parabolic system derived from the Keller-Segel model describing chemotaxis. Moreover, we establish the existence and the nonlinear stability of large-amplitude traveling wave solutions to the system of nonlinear conservation laws derived from KS model.

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MS60

The Hyperbolic Keller-Segel Model and Branching Instabilities

A remarquable feature of cell colonies are their ability to invade surfaces with dentritic patterns expressing an evolved strategy to look for the best conditions for growth. There are very few PDE models undergoing such branching instability. Among those, one of the most famous is known as Mimura's model. It describes the growth of a cell population under the effect of a nutrient which is locally depleted by the colony and thus cells that are in advance have an advantage for multiplication. Discussions with biologists runing experiments on very rich media motivated us to search for another possible mechanism. We consider a model which is based on a conservative parabolic system and that undergoes branching instabilities. The swarmer cells are modeled by a Fokker-Planck type equation à la Keller-Segel, coupled with two fields describing attraction and repulsion. It also includes the 'quorum sensing' limitation proposed by Dolak and Schmeiser. Extended models are more realsitic and reduced systems are analytically tractable. They explain stability and unstability of plateau type traveling wave solutions. This lecture is based on collaborations with F. Cerreti, Ch. Schmeiser, M. Tang and N. Vauchelet.

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MS60

Global Dynamics of a Diffuse Interface Model for Solid Tumor Growth

In this talk I will report recent progress on a diffuse interface model (referred as the Cahn-Hilliard-Hele-Shaw system) which arises in modeling of spinodal decomposition in binary fluid in a Hele-Shaw cell, tumor growth and cell sorting, and two phase flows in porous media. Previous nuemrical simulations showed that the model is capable of modeling all the stages of a solid tumor growth - avascular, vascular and metastasis. In this work, wellposedness, regularity and long-time asymptotic behavior of solutions to an initial-boundary value problem of the model are rigorously justified.

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MS61
On the Validity of the NLS Equation in Systems with Quadratic Resonances

For a nonlinear wave equation possessing quadratic resonances, we address the validity question concerning the approximation obtained via a formally derived nonlinear Schrödinger (NLS) equation. In analyzing the resonances one arrives at a three-wave interaction (TWI) system. We make connections between the validity of the NLS approximation and the stability of the TWI system associated to the resonance. Numerical simulations illustrate the results and offer insight to situations where the analysis is unclear.

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MS61
Approximation Theorems for the Water Wave Problem in the Arc Length Formulation

There are several proofs that long–wavelength solutions to the two–dimensional water wave problem with finite depth can be approximated by solutions of the Korteweg–de Vries equation or the Kawahara equation. We provide a new proof, which is simpler, more elementary and shorter. Moreover, the justification of the KdV approximation can be given for the cases with and without surface tension together by one proof. In our proof, we parametrize the free surface by arc length.

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MS61
Stability of Solitary waves in the KdV Limit for Fluid and Lattice Models

I will describe recent work with Shu-Ming Sun on asymptotic linear stability (a linearized scattering result) for small-amplitude solitary water waves with no surface tension over a flat bottom, and related nonlinear stability results for model equations for lattices and fluids. A significant feature of the analysis is the effective use of known stability properties of solvable models such as KdV and Toda lattice equations.

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MS61
A Rigorous Justification of the Modulation Approximation to the 2D Full Water Wave Problem

We consider the 2D inviscid incompressible irrotational infinite depth water wave problem neglecting surface tension. Given wave packet initial data of the form $\alpha + \epsilon B(\epsilon\alpha)e^{ik\alpha}$ for $k > 0$, we show that the modulation of the solution is a profile traveling at group velocity and governed by a focusing cubic nonlinear Schrödinger equation, with rigorous error estimates in Sobolev spaces. As a consequence, we establish existence of solutions of the water wave problem in Sobolev spaces for times of order $O(\epsilon^{-2})$ provided the initial data differs from the wave packet by at most $O(\epsilon^{3/2})$ in Sobolev spaces. These results are obtained by directly applying modulational analysis to the evolution equation with no quadratic nonlinearity constructed in the paper of S. Wu (2009) and by the energy method.

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MS61
Justification of the NLS Approximation for a Quasi-linear Water Wave Model

I will show how for a quasilinear water wave model the NLS approximation can be justified. The model presents several new difficulties due to the quadratic terms which have to be eliminated by a normal-form transformation. Due to the quasilinearity of the problem there is some loss of regularity associated with the normal-form transformation and there is a nontrivial resonance present in the problem. The loss of regularity is dealt with by using a Cauchy–Kowalevskaya-like method to treat the initial value problem and the nontrivial resonance is dealt with via a rescaling argument.

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MS62
Numerical Methods for SPDEs based on Fluctuation-Dissipation Balance: Applications to Implicit Solvent Models with Fluctuating Hydrodynamics

Many challenges arise in the numerical approximation of Stochastic Partial Differential Equations (SPDEs). This includes the need to approximate solutions that are often highly irregular (non-differentiable in space and time), the need to discretize and to generate stochastic driving fields that yield accurate dynamics, and the need to resolve stochastic dynamics often exhibiting significant stiffness. To cope with these issues spectral numerical methods are often used. However, such methods require in practice often rather simple domain geometries and fast transforms. We discuss alternative approaches based on finite difference discretizations and on ideas from statistical mechanics. For a class of SPDEs of parabolic type we develop discretizations for stochastic driving fields by formulating

a fluctuation-dissipation principle for the control of numerical truncation errors. We demonstrate how this approach can be used to develop discretizations for spatially adaptive meshes and for domains having complex geometries with imposed Neumann or Dirichlet boundary conditions. We present evidence that these methods converge weakly for this class of SPDEs. As a specific application of these approaches we show how stochastic hydrodynamics can be incorporated into implicit solvent models for the study of molecular systems. In particular, we discuss a dynamic implicit solvent model for lipid bilayer membranes with protein inclusions which involve SPDEs that capture consistently the hydrodynamics, elastic mechanics, and thermal fluctuations.

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MS62

Composition Dynamics in Multicomponent Lipid Bilayer Membranes

We develop a stochastic phase-field model for multicomponent lipid bilayers that includes the quasi-two-dimensional hydrodynamics appropriate to a membrane surrounded by a viscous fluid, simulating ten micron systems for tens of seconds. We compare directly to fluorescence microscopy experiments on multicomponent vesicles, and use theory motivated by these simulations to probe membrane viscoelastic parameters. The dynamics of domain coarsening and diffusion of membrane-embedded objects are also discussed.

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MS62

Stochastic Models of Nucleation and Aggregation in Confined Spaces

The classic problem of homogeneous nucleation is examined within a finite-sized, stochastic framework. We derive a high-dimensional stochastic Master Equation describing the evolution of the concentrations of homogeneously nucleating clusters. Through careful enumeration of steady-state cluster configurations, we find recursion relations for determining quenched cluster configurations as well as exact analytical formulae for the equilibrium mean cluster size distribution. Our analysis of the full stochastic problem yields mean cluster size distributions that are qualitatively different from those derived from the corresponding mean-field, mass-action Becker-Döring equations. Not only do the final equilibrium mean cluster size distribution differ dramatically, but coarsening behavior often seen in mass-action models of nucleation largely disappears. The magnitude of these differences depends primarily on the divisibility of the total monomer mass by the maximum cluster size, and the remainder. Thus, strong finite-size and stochastic effects arise even when both total mass and maximum cluster sizes are unbounded, provided thier ratio is finite. Our results indicate limits of validity of the classic mass-action Becker-Döring equations and were all verified using extensive kinetic Monte-Carlo simulations.

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MS62

Anomalous Diffusion through Protective Biological Fluid Layers

I will survey the Generalized Langevin Equation and alternative models for a field known as passive microbead rheology. The idea is classical: to measure fluctuations of a probe particle to infer dissipative properties. In this case, the idea is to expand fluctuation-dissipation to viscoelastic fluids, and soft biological materials in particular. I will survey progress by our group in modeling, semi-analytical, and simulation tools for inference from experimental data and direct simulations of paths, mean-squared displacement statistics, and first passage times.

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MS63

Wave Propagation in Time Dependent Randomly Layered Media

I will describe the cumulative scattering effects on wave front propagation in time dependent randomly layered media. It is well known that the wave front has a deterministic characterization in time independent media, aside from a small random shift in the travel time. That is, the pulse shape is stable, but faded and smeared as described mathematically by a convolution kernel determined by the second order statistics of the random fluctuations of the wave speed. I will describe the extension of the pulse stabilization results to time dependent randomly layered media.

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MS63

Stability and Resolution Analysis for a Topological-derivative-based Imaging Functional in Random

Media

In this talk we introduce and study a topological-derivative-based anomaly detection algorithm. We investigate its stability when the medium is random as well as its resolution. A postprocessing of the data set is introduced and shown to be essential in order to obtain an efficient topological-derivative-based imaging functional, both in terms of resolution and stability.

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MS63

Inverse Source Problem in Random Media

Abstract not available at time of publication.

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MS63

Shock Profiles in Random Media

I will introduce and discuss some large deviation problems for conservation laws as they arise in a number of applications in flow and combustion. I will then discuss the form of the rate function for the large deviations and analyze some of its properties for shock profiles.

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MS64

CahnHilliard Equations with Memory and Dynamic Boundary Conditions

We consider a Cahn-Hilliard equation where the velocity of the order parameter depends on the past history of the Laplacian of the chemical potential. This dependence is expressed through a time convolution integral characterized by a smooth non-negative exponentially decreasing memory kernel. The chemical potential is subject to the no-flux condition, while the order parameter satisfies a (nonlinear) dynamic boundary condition. The latter accounts for possible interactions with the container walls. We illustrate the results we have obtained in the viscous case, namely, well-posedness, existence of a smooth global attractor, existence of exponential attractors. In the non-viscous case, the existence of a trajectory attractor is also established.

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MS64

Long time Behavior of the Caginalp System with Singular Potentials and Dynamic Boundary Conditions

This talk is devoted to the well-posedness and the long time behavior of the Caginalp phase-field model with singular potentials and dynamic boundary conditions. Thanks to a suitable definition of solutions, coinciding with the strong ones under proper assumptions on the bulk and surface potentials, we are able to get dissipative estimates, leading to the existence of the global attractor with finite fractal dimension, as well as of an exponential attractor.

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MS64

Nonlinear Wave Equations with Strong Damping and Nonlinear Damping Terms

We study initial boundary value problems for nonlinear wave equations with strong damping and nonlinear damping terms. The problems of global existence and uniqueness , regularity and blow up of solutions , existence of global attractors of dynamical systems generated by problems under consideration will be discussed. This is a joint work with S.Zelik.

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MS65

Uniqueness for the Homogeneous Willmore Dirich-

let Boundary Value Problem

The Willmore functional associates to a surface the integral over the surface of its mean curvature squared. This functional is conformally invariant. The corresponding Euler-Lagrange equation (the Willmore equation) is a fourth order non-linear elliptic equation. The study of this equation together with boundary conditions is challenging. In this talk we present a uniqueness result for the homogeneous Willmore Dirichlet boundary value problem for graphs over strictly star-shaped domains.

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MS65

Area Constrainded Willmore Surfaces in Riemannian Manifolds

Abstract not available at time of publication.

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MS65

Very Weakly Biharmonic Maps into Homogeneous Spaces

Intrinsic biharmonic maps are the critical points of a functional involving second derivatives for maps between Riemannian manifolds. Formal calculations give an Euler-Lagrange equation for this problem of fourth order. But this equation has a meaningful interpretation only in a Sobolev space that is smaller than the natural space for the variational problem. If the target manifold is a homogeneous space, then it is possible to rewrite the equation and close the gap between the variational problem and the PDE. We can then also prove conditional regularity results under very weak initial assumptions of the solutions.

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MS65

The Gradient Flow of the L^2 Norm of the Riemannian Curvature Tensor

The L^2 norm of the Riemannian curvature tensor is a natural analogue of the Yang-Mills energy. Critical metrics of this functional include natural generalizations of Einstein metrics. The gradient flow of this functional is a natural approach to understanding the structure of the space of metrics and the existence of critical points. I will discuss some long time existence results in subcritical dimensions, as well as in "low energy" cases in the critical dimension 4, and discuss the main obstruction to extending these results further.

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MS66

Regularity of Rotational Travelling Water Waves

Several recent results on the regularity of streamlines beneath a rotational travelling wave, along with the wave profile itself will be discussed. The topic includes the classical wave problem in both finite and infinite depth, capillary waves, and solitary waves as well. A common assumption in all models to be discussed is the absence of stagnation points.

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MS66

The Water Wave Problem via Conformal Mappings

I will speak on functional analytic properties of small-amplitude solitary waves on the free surface of a two-dimensional steady flow of water over a finite bed, acted upon by gravity as well as surface tension. I will begin by formulating the water wave problem by combining Zakharov's Hamiltonian and conformal mappings; its steady wave problem reduces to a nonlocal nonlinear equation, analogous to Babenko's equation for Stokes waves. I will show how the Korteweg-de Vries equation arises as the leading-order approximation in a certain weakly-nonlinear long-wave regime. I will then discuss the existence of solitary-wave solutions as an application of the implicit function theorem and implications for their linear stability.

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MS66

Instability of Periodic Water Waves

Periodic traveling waves exist in 2D water waves and many dispersive wave models, such as Stokes waves of deep water (Stokes, 1847) and Cnoidal waves of KDV equation. I will discuss an approach to find stability criteria for periodic waves of water waves and many dispersive wave models, under perturbations of the same period. The results include a sharp instability criterion for KDV and BBM type models, and a proof of the existence of unstable Stokes waves under some natural assumptions. The perturbations with different periods will also be briefly discussed.

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MS66

Rotational Steady Periodic Water Waves with Stagnation Points

Consider inviscid 2D water waves of finite depth under the influence of gravity. We assume they have constant vorticity γ, travel at speed c, and have horizontal period L. The water waves may have stagnation points. Let h be the conformal depth. Then for any values of γ, c, L and h, there exists a global curve $\mathcal{K}$ of such water waves with the following properties. (i) They have a single crest and trough per period and are monotone in between. (ii) At one end, the curve bifurcates from a laminar flow. (iii) At the other end, either the curve approaches stagnation at the crest, or it approaches the vertical somewhere on the free surface. This is joint work with A. Constantin and E. Varvaruca.

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MS67

Boundary Effect and Turbulence

The most common criteria for turbulence, in statistical theory of turbulence, in numerical simulations and in experiments is the existence of anomalous : the fact that with Reynolds number going to ∞ the entropy dissipation does not converges to 0 or with $\nu = \frac{1}{\mathcal{R}\rceil}$

$$\lim_{\nu\to\infty} \nu \int \|\nabla u_\nu\|^2 dx \to \epsilon > 0$$

It is in presence of boundary effect that a mathematical formulation can be provided. This relies on a simple but very clever theorem of Kato. I will show how this depends on the nature of the boundary effect and exhibit similarity between Navier-Stokes and Boltzmann limit

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MS67

Large Time Behavior for Vorticity Formulation of a 2-D Incompressible Flow Model

The vorticity formulation of 2-D incompressible Navier-Stokes equation can be viewed as mean-field limit of stochastic interacting point vortices. In such model context, the action functional for probabilistic large deviation principle (large particle number limit) characterizes Boltzmann entropy for the stochastic system in path space, in any finite time. It characterizes fluctuation around incompressible Euler equation. By studying a large time and inviscid limit of such functional as a variational/optimal control problem in space of measures, we give a scheme under which large time coherent structure for the associated complex flows can be justified. We will use the tools of large deviation, Hamilton-Jacobi equation in space of measures and optimal mass transportation theory to explain the procedure. The talk is based on joint work with a number of coauthors.

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MS67

The incompressible Euler Equations as a Limit of Euler-α Models

The Lagrangian-averaged Euler equations or Euler-α equations, introduced by D. Holm, J. Marsden and T. Ratiu in 1998, are a desingularization of the incompressible Euler equations. Convergence of Euler-α to the Euler equations, as $\alpha \to 0$, has been studied in domains without boundary. In this talk we discuss recent results on convergence in the presence of boundaries. Motivated by the second grade model for complex fluids, we consider zero tangential "stress" at the boundary and we relate this to the well-known Newtonian Navier free slip boundary condition, which we use as boundary condition for Euler-α. We prove convergence to solutions of the incompressible Euler equations in a bounded domain with free slip boundary conditions, under the hypothesis that there exists a uniform time of existence for the approximations, independent of α. This additional hypothesis is not necessary in 2D, where global existence is known, and for axisymmetric flows without swirl, for which we prove global existence. In summary, we obtain strong convergence in L^2, as $\alpha \to 0$, to a solution of the incompressible Euler equations, assuming smooth initial data.

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MS67

Riesz Transforms and the Helmholtz-Hodge Decomposition – Probabilistic Methods with Applications to the Equations of Fluid Mechanics

I will survey recent and ongoing work with HoeWoon Kim and Ed Waymire on the use of probabilistic methods in the representation of solutions of the equations of Fluid Mechanics in domains with boundaries. In particular, we use a recently developed probabilistic representation of the iterated Riesz transforms in connection with the Helmholtz-Hodge decomposition in R^3. This work is based in part in HoeWoon Kim PhD thesis.

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MS68

Dynamics and Hopf Bifurcation in the Gierer-Meinhardt System

Some reaction-diffusion systems like the Gierer-Meinhardt system exhibit spot patterns. Actually, multiple spots must be unstable and only a single spot is observed in the shadow system, which is a limiting system as a diffusion coefficient goes to infinity. Hence we can simplify the system which describes the dynamics of spots and show that Hopf bifurcation of a single spot. We clarify how parameters in the system influence the bifurcation by this reduced system.

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MS68

Competition and Oscillation Instabilities in the Near-shadow Limit of Certain Reaction-diffusion Systems

We consider a well-known two-component RD system of the form $u_t = \varepsilon^2 u_{xx} + f(u,v), \ \ \tau v_t = D v_{xx} + g(u,v)$ in the limit of small ε and large D. Under certain generic conditions on the nonlinearities, such system admits solutions consisting of $2K$ interfaces that are known to be stable for large but finite D. On the other hand, it is also well known that in the limit $D = \infty$, only a single interface solution can be stable. We show that the transition to instability occurs when D is exponentially large in ε, and we explicitly compute the instability thresholds. Another type of instability is possible when $\tau = O(D/\varepsilon)$. In this case, the interfaces can oscillate. We show that this is a result of a supercritical Hopf bifurcation and we explicitly compute the amplitude of the oscillations, even far from the Hopf bifurcation point. Joint works with Rebecca McKay.

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MS68

Trapped Vortices in the Large-density (Thomas-Fermi) Limit

The Gross-Pitaevskii equation with a harmonic potential and repulsive nonlinear interactions is considered in the large-density limit, also known as the Thomas-Fermi limit. In the space of two dimensions, we employ the Rayleigh-Ritz method to obtain variational approximations of single vortices, dipole pairs, and quadrupoles trapped in the harmonic potential. In particular, we compute the eigenfrequency of the single vortex precession about the center of symmetry of the harmonic potential, as well as the eigenfrequencies of the oscillations of the dipole and quadrupole vortex configurations. The asymptotic results are illustrated by the numerical computations. This is a joint work with P. Kevrekidis (University of Massachussets).

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MS68

Concentration Behavior in Fourth Order Nonlinear Eigenvalue Problems of MEMS

Using formal asymptotic and numerical methods we construct the global bifurcation diagram of radially symmetric solutions in the unit disk in 2-D for a nonlinear Biharmonic eigenvalue problem. This problem models the steady-state deflection of an elastic membrane associated with a MEMS capacitor under a constant applied voltage in a narrow-gap limit. For $\delta > 0$, the steady-state deflection $u(|x|)$, with $0 < |x| < 1$, satisfies $-\delta\Delta^2 u + \Delta u = \lambda/(1+u)^2$ with $u = u_n = 0$ on $|x| = 1$, where λ is the bifurcation parameter. When $\delta = 0$, it is well-known that the limiting second-order nonlinear eigenvalue problem has an infinite fold-point structure. For $\delta > 0$, we show that this infinite fold-point structure is destroyed and that there is a maximal solution branch for which $\lambda \to 0$ as $\epsilon \equiv 1 - ||u||_\infty \to 0^+$. A precise asymptotic description of this concentration behavior is obtained, and the results are favorably compared with full numerical results.

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MS69

On Some Properties of the Navier-Stokes Equation on the Hyperbolic Space

Finite energy and finite dissipation solutions to the Navier-Stokes equation on a two dimensional hyperbolic space are nonunique. We discuss possible ways to arrive at uniqueness of solutions in the hyperbolic setting.

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MS69

Asymptotic Behavior of a Determining Form for the 2D Navier-Stokes Equations

Recently we have developed a determining form, which is an ordinary differential equation in the Banach space of time-dependent functions taking values in the determining low modes of the Navier-Stokes equations (NSE). If the initial condition for the ODE is the low-mode projection of a solution on the global attractor of the NSE, the solution of the determining form evolves as a traveling wave. In fact these are the only traveling waves for the determining form. In this talk we discuss how an arbitrary initial trajectory evolves under the flow of the determining form toward a solution of the NSE.

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MS69

Complexity of Solutions for Parabolic Equations with Gevrey Coefficients

We provide a quantitative estimate of unique continuation for high order parabolic equations (including the Navier-Stokes equations) with non-analytic Gevrey coefficients. We also provide a new upper bound for the number of spacial oscillations with polynomial dependence of coefficients. This is joint work with Mihaela Ignatova.

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MS69

Boundary Layer Analysis and Vanishing Viscosity Limit for Pipe Flows

I will present recent work on the analysis of the boundary layer and the limit of vanishing viscosity for certain incompressible, Newtonian flows in circular pipes.

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MS69

A Parabolic Approximation of Incompressible Fluid Equations

We consider the Cauchy problem for a nonlinear parabolic system $u_t - u + u \cdot \nabla u + \frac{1}{2} u \mathrm{div} u - \frac{1}{\epsilon} \mathrm{div} u = 0$ in R^3 with initial data in Lebesgue spaces$L^2(R^3)$ or $L^3(R^3)$. We analyze the convergence of its solutions to a solution of the incompressible NavierStokes system as 0 and the questions of partial regularity.

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MS70

Stability of Coupled Oscillators on a Graph

There are a number of models of physical and biological interest which take the form of a (usually large) number of oscillators coupled weakly together. In situations where the system is stochastically forced one is interested not only in stable solutions but in solutions with one unstable direction, as these represent stationary paths connecting local minima. We establish some index results counting unstable directions for these problems. We use these results to prove some rigorous estimates on the probability of synchronization when the oscillator frequencies are chosen randomly according to a Guassian distribution.

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MS70

Geometric Evolution of Interfaces in the Functionalized Cahn-Hilliard Equation

The functionalized Cahn-Hilliard energy (FCH) is a novel higher-order energy that serves as a model for network formation in solvated, functionalized polymers. Leading order minimizers of this energy include new bi-layer solutions with homoclinic cross sections. An overview of the reduction of the gradient flow of (FCH) to the sharp interface evolution is presented.

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MS70

Title Not Available at Time of Publication

Abstract not available at time of publication.

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MS70

On the Natural Frequencies of a Free/free Goupillard-type Elastic Strip

We consider a layered Goupillaud-type elastic medium (equal wave travel time for each layer). The natural frequencies of a free/free Goupillaud-type strip are described analytically using two different approaches: 1) Solving the frequency equation after applying a transformation of the spatial variable. 2) Converting the resonance frequency results obtained when a discrete forcing function that varies harmonically with time is applied at one end of the strip, while the other end is free.

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MS71

A Rigorous Proof of the Maxwell-Claussius-Mossotti Formula

We consider a large number of identical inclusions (say spherical), in a bounded domain, with conductivity different than that of the matrix. In the dilute limit, with some mild assumption on the first few marginal probability distribution (no periodicity or stationarity are assumed), we prove convergence in $H1$ norm of the expectation of the solution of the steady state heat equation, to the solution of an effective medium problem which for spherical inclusions is obtained through the Maxwell-Clausius-Mossotti formula. Error estimates are provided as well.

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MS71

Global Minimizers for a p-Ginzburg-Landau Energy When p goes to Infinity

We consider the minimization problem of the energy functional

$$E_p(u) = \int_{\mathbf{R^2}} |\nabla u|^p + (1 - |u|^2)^2$$

for $p > 2$ over the space of maps in $W^{1,p}_{loc}(\mathbf{R^2}, \mathbf{R^2})$ whose degree along circles of large radii is 1. We first review previous works where: (i) we proved existence of a minimizer for any $p > 2$, (ii) we obtained some properties of the minimizers over the class of radially symmetric maps. We then report on some recent results on the limit of the minimizers u_p when p tends to infinity. This is a joint work with Y. Almog, L. Berlyand and D. Golovaty.

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MS71

Behavior of Ginzburg-Landau Vortices on a Surface

I will discuss some recent results regarding existence/nonexistence of stable vortex solutions to Ginzburg-Landau posed on a manifold. Time permitting, results will be discussed for critical points, solutions of the GL heat flow and solutions of the dispersive Gross-Pitaevskii dynamics in this context.

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MS72

Dynamical Problems Arising in the Modeling of Polyelectrolyte Gels

Abstract not available at time of publication.

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MS72

Phase Separation in Diblock Copolymers

Abstract not available at time of publication.

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MS72

Regularity for a Strongly Anisotropic Free Boundary Problem

We will present a variational free boundary problem involving 2D linear elasticity and highly anisotropic surface energy. We will be mainly concerned with the regularity of the free boundary for minimal configurations in the crystalline and strictly convex cases. This is a joint work with I. Fonseca, N. Fusco, and G. Leoni.

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MS72

Analysis of Chevron Patterns in Liquid Crystals by Way of Gamma Convergence

We investigate the structure of a smectic C liquid crystal body trapped between two parallel plates. This is modeled using the Chen-Lubensky energy that couples a second order energy that accounts for smectic layer formation and the first order nematic Frank energy. In the smectic C phase the smectic layers meet the plates at an acute angle. In order for this to happen the layers' profiles should form a zig-zag or chevron pattern. We prove that these patterns occur in minimizers for this model, for the case that the layer bending constant is small. We do this using gamma convergence.

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MS73

Arterial Blood Flow Modeling: Analysis, Computations and Applications

We will present some new ideas related to the mathematical and numerical modeling of arterial blood flow. We will discuss the design of stable loosely-coupled numerical algorithms, where the original problem is split in a sequence of simpler sub-problems. We will show how stability can be achieved by exploiting the mixed hyperbolic/parabolic features of the problem.

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MS73

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 treatment 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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MS73

Attractor for a Non-dissipative von Karman Plate with damping in Free Boundary Conditions

I will discuss a plate equation suggested by certain flow-structure interaction models: a von Karman plate with a first order non-dissipative term in the interior. Because of

this perturbation the resulting dynamical system is of a non-gradient type. Moreover, the dissipative velocity feedback is applied through the free boundary conditions only. It will be shown that despite the lack of monotonicity and absence of interior damping this flow can converge to a global compact attractor.

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MS73

A Third Order PDE arising in High-Intensity Ultrasound: Structural Decomposition, Spectral Analysis, and Exponential Stability

This presentation describes an abstract third-order equation motivated by the Moore–Gibson–Thompson Equation arising in high-intensity ultrasound. In its simplest form, the equation (with unbounded free dynamical operator) is not well-posed. However, a suitable change of variables permits one to show that it has a special structural decomposition, with a precise, hyperbolic-dominated part. Significant dynamical properties of the system, including spectral analysis and sharp stability estimates, will be presented and corroborated by numerical simulations.

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MS73

Strong Well-posedness and Long-time Behavior of the Two-phase Navier-Stokes Equations with Surface Tension

In this talk I present results on local well-posedness and qualitative behavior of solutions to the two-phase incompressible Navier-Stokes equations with surface tension. In particular, the equilibria are stable and each solution which is initially close to an equilibrium exists for all times and it converges to an equilibrium at an exponential rate. This is joint work with M. Köhne and J. Prüss.

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MS74

Title Not Available at Time of Publication

Abstract not available at time of publication.

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MS74

Global Solutions for Transonic Self-similar Two-dimensional Riemann Problems

We discuss the global self-similar solutions for transonic Riemann problems.

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MS74

Balance Laws: Existence, Asymptotics and Singular Limits

Results on models arising in continuum physics will be discussed. Issues of existence and asymptotic behavior will be analyzed.

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MS74

Riemann Problems for Two Dimensional Euler Systems

We present solutions to Riemann problems for the Euler system in two space dimensions in some special cases.

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MS75

A Mathematical Model of Glioma Invasion

Glioblastoma is a highly invasive brain tumor. This invasive behavior of tumor cells is responsible for low survival rate and microenvironment plays an important role in the active migration. A thorough understanding of the microenvironment would provide a foundation to generate new strategies in therapeutic drug development. We developed a mathematical model to better understand the role of microenvironment in creating different invasion patterns. We analyze the migration patterns of glioma cells from the main tumor, and show that the various patterns observed in experiments can be obtained by a model's simulations, by choosing appropriate values of the key model parameters of the PDE model. These includes chemotactic sensitivity, haptotactic strength, and cell-cell adhesion. Cancer is a complex, multiscale process, in which genetic mutations occurring at a sub-cellular level manifest themselves as functional changes at the cellular and tissue scale. A hybrid model will also be discussed in order to get more detailed information on cell migration and growth under the influence of a particular microRNA (miR451).

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MS75

Virtual Melanoma: When, Where and How Much to Cut

Through our spatiotemporal model of melanoma, we observe that immune cells can destroy tumors and also at times induce tumorigenic expansion through the production of angiogenic factors. We observe that small metastatic lesions distal to the primary tumor mass can be held to a minimal size via the immune interaction with the larger primary tumor and satellite lesions can become aggressively tumorigenic upon removal of the primary tumor and its associated immune tissue.

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MS75

Title Not Available at Time of Publication

Abstract not available at time of publication.

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MS75

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MS76

The Two-phase Stefan Problem: Regularization near Initial Lipschitz Data

In this talk we will review the regularity theory of Hele-Shaw and Stefan-type problems and discuss recent developments.

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MS76

Degenerate Convection Diffusion Equstions: Decay Rate and Global Regularity

We consider degenerate convection-diffusion equations. We are concerned with the regularity estimate of solutions of general convection diffusion equation and we obtain a regular estimate under certain assupmtions on the degeneracy of the diffusion coefficients. Next we study the time-decay rate of solutions of the same equations. We obtain a new decay rate under certain conditions: the L-infinity norm of the solution decays like time to the power minus alpha, where alpha lies between zero and one half. The analysis depends on a Lax Oleinik type estimate.

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MS76

A Liouville Theorem for the Axially-symmetric Navier-Stokes Equations

Let $v(x,t) = v^r e_r + v^\theta e_\theta + v^z e_z$ be a solution to the three-dimensional incompressible axially-symmetric Navier-Stokes equations. Denote by $b = v^r e_r + v^z e_z$ the radial-axial vector field. Under a general scaling invariant condition on b, we prove that the quantity $\Gamma = rv^\theta$ is Hölder continuous at $r = 0$, $t = 0$. As an application, we prove that bounded ancient weak solutions of axis symmetric Navier-Stokes equations are zero provided that $b \in L^\infty([0,T], BMO^{-1})$. As another application, we prove that if $b \in L^\infty([0,T], BMO^{-1})$, then v is regular.

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MS77

Scattering for the Mass-critical Nonlinear

Schroedinger Equations

Abstract not available at time of publication.

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MS77

Nonlinear Bound States on Manifolds

We will discuss the results of several joint projects (with subsets of collaborators Pierre Albin, Hans Christianson, Jason Metcalfe, Michael Taylor and Laurent Thomann), which explore the existence, stability and dynamics of nonlinear bound states and quasimodes on manifolds of both positive and negative curvature with various symmetry properties.

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MS77

Decay for Wave Equations on Black Hole Backgrounds

Abstract not available at time of publication.

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MS77

Dynamics of Blow up Solutions to the NLS Equation

We discuss dynamics of blow-up solutions to the focusing NLS equations in the L^2-critical and L^2-supercritical cases. In particular, we show that the log-log blow-up solutions to the L^2-critical equation, studied by Merle-Raphael, remain regular in the energy space away from the blow-up point. This implies, for example, that there exist H^1 radial blow-up solutions on a sphere for the 3d quintic (energy-critical) NLS equation, thus, improving the result of Raphael-Szeftel (2008).

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MS78

An Integral Equation Approach for Media with Close or Touching Inclusions

We consider a system of integral equations for the potential in a 2D composite conductive medium, that contains close to touching inclusions. When the inclusions are disks, we relate the spectral properties of the integral operator to pointwise bounds on the potential gradients, in terms of the conductivity contrast and inter-inclusion distance.

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MS78

Resistor Network Approaches to the Inverse Problem of Electrical Impedance Tomography

Abstract not available at time of publication.

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MS78

Analysis of Some Numerical Methods in Stochastic Homogenization

In this talk I'll focus on the simplest possible setting for stochastic homogenization: a discrete elliptic equation on Z^d with i.i.d. conductivities. I'll present and quantitatively analyze three different methods to compute the homogenized coefficients: approximations using the corrector equation regularized by a zero-order term, approximation by periodization, and simulation of the random walk in the random environment by a Monte-Carlo method. This talk is based on joint works with J.-C. Mourrat (EPFL), S. Neukamm (MPI Leipzig), and F. Otto (MPI Leipzig).

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MS78

Asymptotics of Solutions of the Random Schroedinger Equation

Abstract not available at time of publication.

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MS79

Fast Numerical Solvers for the Infinity Laplace Equation and Methods for Minimal Distortion Mappings in the Plane

We build discretizations and semi-implicit solvers for the ∞-Laplacian and the game theoretical p-Laplacian, which interpolates between the ∞-Laplacian and the Laplacian. We prove convergence of the solution of the Wide Stencil finite difference schemes to the unique viscosity solution of the underlying equation. We build a semi-implicit solver, which is faster than explicit solution methods. In particular, the convergence rate is independent of the problem size. Joint with Selim Esedoglu.

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MS79

Existence of Absolute Minimizers for Noncoercive

Hamiltonians and Viscosity Solutions of Aronsson Equation

I will discuss the notion of absolute minimizers and the corresponding Aronsson equation for a noncoercive Hamiltonian. We can extend the definition of absolutely minimizing functions (in a viscosity sense) for the minimization of the L^∞ norm of a Hamiltonian, within a class of locally Lipschitz continuous functions with respect to possibly noneuclidian metrics. The metric structure is naturally associated to the Hamiltonian and it is related to the a-priori regularity of the family of subsolutions of the Hamilton-Jacobi equation. A special but relevant case contained in our framework is that of Hamiltonians with a Carnot-Caratheodory metric structure determined by a family of vector fields, in particular the eikonal Hamiltonian and the corresponding anisotropic infinity-Laplace equation. In this case, the definition of absolute minimizer can be written in an almost classical way, by the theory of Sobolev spaces in a Carnot-Caratheodory setting. In general open domains and with a prescribed continuous Dirichlet boundary condition, we prove the existence of an absolute minimizer and derive the Aronsson equation as a viscosity solution for such a minimizer. The proof is based on Perron's method and relies on a-priori continuity estimates for absolute minimizers.

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MS79

Remarks on the Large Time Behavior of Viscosity Solutions of Quasi-monotone Weakly Coupled Systems of Hamilton–Jacobi Equations

We investigate the large-time behavior of viscosity solutions of quasi-monotone weakly coupled systems of HamiltonJacobi equations on the n-dimensional torus. We establish a convergence result to asymptotic solutions as time goes to infinity under rather restricted assumptions. Joint work with H. Mitake.

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MS79

Several Things Related to the Regularity of Infinity Harmonic Functions

I will discuss several things related to the regularity of infinity harmonic functions, such as the failure of the usual flatness argument, another way to derive the Crandall-Evans's blow-up result, etc.

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MS80

Regularity Theory for Solutions of Fully Nonlinear Integro-differential Parabolic Equations

We study the regularity of solutions of parabolic fully nonlinear nonlocal equations. We prove first Hölder regularity in space and time which allows us to prove Höder regularity for the first derivative when the equation is translation invariant and under a special assumption on the kernels. The proof relies on a weak parabolic ABP that we obtain by covering the contact set with rectangles where the function doesn't separates too much from its convex (parabolic) envelope in a given fraction of the covering. Finally we use some ideas from L. Wang, "On the Regularity Theory of Fully Nonlinear Parabolic Equations: I" to get a point estimate which implies the diminish of oscillation lemma. Same as in the previous work by L. Caffarelli and L. Silvestre, our intention is to present results that remain uniform as the order of the equation goes to 2, giving some unification between the non local and the classical theory.

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MS80

On the Supercritical SQG Equation

We will show that smooth solutions to the supercritical dissipative surface quasi-geostrophic equation eventually become smooth by uniformly bounding the Holder C^β norm of the solution. We will do this by considering how the dynamics of the equation alter a class of functions dual to C^β.

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MS80

L_p and Schauder Estimates for a Class of Nonlocal Elliptic Operators

I will discuss some recent results about L_p and Schauder estimates for a class of non-local elliptic equations. Compared to previous known results, the novelty of our results is that the kernels of the operators are not necessarily to be homogeneous, regular, or symmetric.

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MS80

A Rigidity Theorem for Nonlocal Mean Curvature

We show how one can extend the celebrated moving plane method of Aleksandrov to show that the only compact hypersurfaces with constant non-local mean curvature are spheres. An interesting outcome of our proof is a kind of Hopf Maximum principle for non-local mean curvature.

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MS81

Gevrey Regularity and Decay of Sobolev Norms of the Navier-Stokes Equations

In this talk, I will show various decay estimates of Sobolev norms of the solutions to the Navier-Stokes. The main idea is to show that mild solutions of the Navier-Stokes equations are in Gevrey classes, which imply the time decay of Sobolev norms of weak solutions immediately. This is a joint work with Professor Biswas at the University of North Carolina at Charlotte.

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MS81

Convergence to Self-similarity for the Boltzmann Equation for Strongly Inelastic Maxwell Molecules

We present a result of propagation of the regularity, uniformly in time, for the scaled solutions of the inelastic Maxwell model for any value of the coefficient of restitution. The result follows from the uniform in time control of the tails of the Fourier transform of the solution, normalized in order to have constant energy. In the case of weak inelasticity, similar results have been established by Carlen, Carrillo and Carvalho (2009).

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MS81

On Local Strong Solvability of the Navier-Stokes Equation

Let $[0,T)$ with $0 < T \leq \infty$ be a time interval and $\Omega \subseteq^3$ a smoothly bounded domain. Consider in $[0,T) \times \Omega$ the non-stationary nonlinear Navier-Stokes equations with prescribed initial value $u_0 \in L^2_\sigma(\Omega)$ and external force $f = F$ with $F \in L^2(0,T;L^2(\Omega))$. It is well-known that there exists at least one weak solution of the Navier-Stokes system in $[0,T) \times \Omega$ in the sense of Leray-Hopf. Since we do not know if these solutions are unique it is an important problem to investigate conditions on the data u_0 and f - as weak as possible - to guarantee the existence of a unique strong solution $u \in L^s(0,T;L^q(\Omega))$ satisfying Serrin's condition $\frac{2}{s} + \frac{3}{q} = 1$ with $2 < s < \infty$, $3 < q < \infty$, at least for $T > 0$ sufficiently small. During the last years several sufficient conditions have been given, yielding step by step a larger class of corresponding local strong solutions. These conditions, however, need not to be necessary, in contrast to our result which is optimal in a certain sense and yields the largest possible class of such local strong solutions.

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MS81

Stokes Pressure and a Navier-Stokes Approximation

An important issue in solving numerically the incompressible Navier-Stokes equations is related to the presence of the pressure, particularly in bounded domains with no-slip boundary conditions. An extension of the Navier-Stokes equations was proposed a few years ago by Bob Pego and collaborators in order to address the specific numerical issues related to the presence of the pressure. This extension reduces to the usual Navier-Stokes when the initial data is divergence free, and for non divergence-free initial data the solution evolves (formally) exponentially toward a Navier-Stokes solution. A specific aspect of the extension is the presence of the so-called Stokes pressure generated by the commutator of the Laplacian with the Helmholtz projection onto divergence-free fields. The Stokes pressure is the main obstacle toward the well-posedness of the extended system, which is the issue we address in this talk.

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MS81

Inverse Problems for some Structured Population Models

Structured population models in biology lead to integro-differential equations that describe the evolution in time of the population density taking into account a given feature such as the age, the size, or the volume. These models possess interesting analytic properties and have been used extensively in a number of areas. After giving an introduction to this subject, we will discuss the inverse problem. In this part, we consider a size-structured model for cell division and address the question of determining the division (birth) rate from the measured stable size distribution of the population. We formulate such question as an inverse problem for an integro-differential equation posed on the half line. We develop firstly a regular dependency theory for the solution in terms of the coefficients and, secondly, a regularization technique for tackling this inverse problem which takes into account the specific nature of the equation. Our results rely also on generalized relative entropy estimates and related Poincare inequalities. This second part is joint work with Benoit Perthame (UPMC, Paris) and Marie Doumic (ENS and INRIA, Paris).

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MS82

Finite-Dimensional Models for Porous-Medium Convection Using a Priori Adapted Bases from Upper-Bound Theory.

We will present a new method for the construction of finite-dimensional dynamical systems approximating the Rayleigh-Benard convection in a fluid-saturated porous medium. The method relies on the derivation of a priori bases specifically tailored to the problem, inspired by energy stability arguments and upper-bound theory. We show that the bases demonstrate dynamically favorable properties, and we present numerical results regarding the convective heat transport, i.e., the Nusselt number, obtained from the dynamical systems.

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MS82

Long-time Behavior of a Geostrophic Two-layer Model for Zonal Jets

In geophysics, multilayer models are derived under the assumption that the fluid consists of a finite number of homogeneous layers of distinct densities. Our model is a two-layer model that was derived to study the perturbation about a zonal jet shear flow. We show that the model is linearly unstable, however the solutions of the nonlinear model are bounded in time. We prove the existence of finite dimensional compact attractor and derive upper bounds on its fractal and Hausdorff dimensions.

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MS82

Numerical Investigations of Infinite Prandtl Number Convection

We describe results of high resolution computations of infinite Prandtl number convection and compute scaling laws for the Nusselt number as a function of the Rayleigh number for free slip boundary conditions in two dimensions. In addition we compare the effect of aspect ratio on flow dynamics and heat transfer rates. Some of this work was performed on Teragrid resources supported by award TG-CTS110010

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MS82

A New Local Well-posedness Framework for the Prandtl Boundary Layer Equations

We address the local well-posedness of the Prandtl boundary layer equations. Using a new change of variables we allow for more general data than previously considered, that is, we require the matching at the top of the boundary layer to be at a polynomial rather than exponential rate. The proof is direct, via analytic energy estimates in

the tangential variables.

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MS82
On The Exact Laws of MHD Turbulence

Exact laws are important properties of turbulent fluids. For MHD turbulence, such laws have been derived by various authors from the statistical point of view. In this talk, we show that these laws hold for weak solutions of the MHD equations, in a distributional sense. As a corollary, we give a simplified proof of the sufficient condition of energy conservation for MHD weak solutions.

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MS83
Invariant Gibbs Measures of the Energy for 3D Models of Turbulence

Gaussian measures of Gibbsian type are associated with some shell model of 3D turbulence; they are constructed by means of the energy, a conserved quantity for the 3D inviscid and unforced shell model. We prove the existence of a unique global flow for a stochastic viscous shell model and of a global flow for the deterministic inviscid shell model, with the property that these Gibbs measures are invariant for these flows. Some results on the 2D case will be discussed.

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MS83
On Energy and Enstrophy Cascades in Physical Scales of the 2D Navier-Stokes Equations

Local analysis of the two dimensional Navier-Stokes equations is used to obtain estimates on the energy and enstrophy fluxes involving Taylor and Kraichnan length scales and the size of the domain. In the framework of zero driving force and non-increasing global energy, these bounds produce sufficient conditions for existence of the direct enstrophy and inverse energy cascades. Several manifestations of locality of the fluxes under these conditions are obtained. All the scales involved are actual physical scales in R^2 and no homogeneity assumptions are made.

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MS83
Stationary Solutions of a Determining Form for the 2D Navier-Stokes Equations

In a 2005 paper with R. Dascaliuc we showed that the global attractor of the 2D Navier-Stokes equations (NSE) achieves a sharp upper bound in the energy,enstrophy-plane if and only if the force is an eigenvalue of the Stokes operator. Recently we have developed a determining form, which is an ordinary differential equation in the Banach space of trajectories in the determining modes for the NSE. The solutions on the global attractor of the NSE are identified as traveling wave solutions of the determining form. In this talk we discuss an extremal property for stationary solutions of the determining form which is analogous to that in the 2005 paper.

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MS83
A Modified Formulation of Statistical Solutions of the Navier-Stokes Equations in Trajectory Space

Great part of the classical theory of turbulence relies on heuristic arguments and empirical information to obtain relations between mean quantities of the flow. The statistical theory of turbulence aims towards a rigorous foundation for the classical theory in the framework of Leray-Hopf weak solutions, in regards to mean quantities based on ensemble averages. The aim in this talk is to introduce a new formulation of the concept of statistical solution based on the definition given by Vishik and Fursikov.

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MS84
T4 Configurations in Fluid Mechanics

In this talk we consider weak solutions of the incompressible 2-D porous media equation. By using the approach of De Lellis-Székelyhidi we show non-uniqueness for solutions in L^∞ in space and time.

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MS84
Global-in-time Properties of the Muskat Problem

The Muskat problem models the dynamics of the interface between two incompressible immiscible fluids with different constant densities. In this talk we discuss three global-in-time results. First we prove an L^2 maximum principle, in the form of a new “log” conservation law which is satisfied by the equation for the interface. Our second result is a proof of global existence for unique strong solutions if the initial data is smaller than an explicitly computable constant, for instance $\|f\|_1 \leq 1/5$. Lastly, we prove a global existence result for Lipschitz continuous solutions with initial data that satisfy $\|f_0\|_{L^\infty} < \infty$ and $\|\partial_x f_0\|_{L^\infty} < 1$. We take advantage of the fact that the bound $\|\partial_x f_0\|_{L^\infty} < 1$ is propagated by solutions, which grants strong compactness properties in comparison to the log conservation law.

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MS84

Analytical Treatment of the Beta-model for Intermittent Energy Cascade

The classical beta-model for intermittent energy cascade is based on the idea that the collection of active eddies at a given dyadic scale fills only a fraction of the volume occupied by active eddies of preceding generation. The Hausdorff dimension of the set where energy dissipates is then determined by the exponential rate of decay of the volumes and relies on an incidence argument. In this talk we will give an analytical interpretation of this so far largely phenomenological argument. Our basic tool is a new formula that measures the active volumes, and active regions are found with the use of atomic decompositions. We introduce precisely the energy dissipation set as the limsup of those active regions and rigorously estimate its Hausdorff dimension.

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MS84

Optimal Large-time Decay Rates for Collisional Kinetic Equations in the Whole Space

In this talk we explain several recent results surrounding the problem of determining the large time behavior of the Boltzmann equation and several related physical kinetic models on the full space (R^3_x). Specifically, in collaboration with R. J. Duan, we introduce new methods which involve a combination of Fourier analytic techniques (in the spirit of Kawashima's work) and the derivation of suitable systems of reduced kinetic equations. These methods enable us to prove the optimal large time decay rates to Maxwellian for several physical models such as the one species Vlasov-Poisson-Boltzmann system and the two-species Vlasov-Maxwell-Boltzmann system. Generalizations to other systems can be expected. Furthemore, since the work of Ukai-Asano in 1982 for cut-off moderately soft potentials, it has been a longstanding open problem to determine the optimal large time decay rates for the soft potential Boltzmann equation in the whole space, with or without the angular cut-off assumption. For perturbative initial data, we prove that solutions converge to the global Maxwellian with the optimal large-time decay rate of $O(t^{-\frac{n}{2}+\frac{n}{2r}})$ in the $L^2_v(L^r_x)$-norm for any $2 \leq r \leq \infty$ in n-dimensions. The proof of existence of global in time unique classical solutions to this system was a joint work with P. Gressman.

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MS85

Stability of Fluid Structure Interaction Problem

In this work we consider the dynamical response of a nonlinear plate interacting with non-linear gradient flow for slightly compressible fluid. The plate part is modeled using a non-linear system of momentum equations for all three components of the vector of the displacement. The fluid flow part is subjected to the generalized Forcheimer equation. Non-standard coupling conditions on the fluid structure interaction surface have been introduced. In particular we show that for a class of boundary conditions and for a specific constraint in the compressibility coefficient , there exists an appropriate energy norm which is bounded by the incoming flow velocity and pressure on the boundary of the liquid region.

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MS85

Multiscale Finite Element Methods for Fluid-structure Interaction Problems

A multiscale framework for fluid-structure interaction problems in inelastic media will be presented. Stokes flow is assumed at the pore scale with a general nonlinear elastic model for deformations. Due to complexity of pore-level interaction an iterative macroscopic model, that consists of nonlinear Darcy equations and upscaled elasticity equations modeled via an iterative procedure, is proposed. Numerical results for the case of linear elastic solid skeleton are presented for a number of model problems.

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MS85

Stability of the Generalised Forchheimer Flow in Porus Media

We study generalized Forchheimer equations for slightly compressible fluids in porous media subjected to the total flux condition on the boundary. We derive estimates for the pressure, its gradient and time derivative in terms of the time-dependent boundary data. For the stability, we establish the continuous dependence of the pressure and pressure gradient on the boundary total flux In particular, we show the asymptotic dependence of the shifted solution on the asymptotic behavior of the boundary data. In order to improve estimates of various types, we prove and utilize suitable Poincare-Sobolev and nonlinear Gronwall inequalities, as well as obtain Gronwall-type inequalities from a system of coupled differential inequalities. We also introduce additional flux-related quantities as controlling parameters of fluid flows for large time in case of unbounded fluxes

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MS85

Evolution Under Constraints: Fate of Methane in Subsurface

Methane gas is stored under the Earth's surface in several forms including i) adsorbed gas in coalbeds and, ii) as part of methane hydrates. In the talk we discuss the associated models for its evolution. Such models involve systems of PDEs coupled with various thermodynamics constraints represented by graphs rather than functions, and, in particular, by inequality constraints and/or hysteresis. This structure of the model(s) presents challenges for analysis and numerical simulation.

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MS85

Qualitative Properties of Nonlinear Parabolic Equations: Regularity and Stabilization

The talk will be dedicated to qualitative theory of nonlinear parabolic PDEs. It will be focused on regularity properies and stabilization of solutions to equations of the p-Laplace and porous medium type. Stabilization of solutions is studied in various setings - both in the whole space (in weighted L^p classes) and in domains. In the latter case we investigate dependence on the geometry of the domain and its connection with admissible classes of initial values.

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MS86

Motion of a Vortex Filament with Axial Flow in the Half Space

We are concerned with a model equation describing the motion of a vortex filament with axial flow immersed in three-dimensional, incompressible, and inviscid fluid. The model equation is a nonlinear third order dispersive system and we prove the time-local unique solvability of an initial-boundary value problem. Since a standard parabolic regularization will not suffice to solve our problem, we propose a new regularization method for a linear dispersive system.

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MS86

Well-posedness for the Two-phase Navier-Stokes Equations with Surface Tension and Surface Viscosity

A rigorous analysis of a sharp-interface model for the flow of two incompressible fluids in a bounded domain is presented. The motion of the moving interface between both fluids is governed by a stress condition which includes both surface tension and surface viscosity according to the Boussinesq-Scriven law. In order to prove local-in-time well-posedness of the model, the following techniques are used: A transformation to a configuration with fixed interface, a localization procedure, the theory of maximal L_p-regularity and the contraction principle.

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MS86

On the Suitable Distance to Control a Perturbed Flow in a Domain with Free Boundary

In the study of stability of steady laminar flows with free boundary, several different linearizations of the unsteady problem have been proposed, in particular the rigorous nonlinear stability theory is still entirely missing. Scope of this note is to begin the study of nonlinear stability of steady laminar flows with free boundary.

Specifically we succeed in the control of a particular distance between the steady Γ_* and unsteady Γ_t surfaces say $\Gamma_t - \Gamma_*$. Such a quantity becomes a distance if Γ_* is the minimum surface. In such a case $\Gamma_t - \Gamma_* > 0$ is always positive. If Γ_t is given as the graph $x_N = \eta(x', t)$, with $\eta \in C^m$, $m \geq 1$, setting $\varphi(x,t) = -x_N + \eta(x', t)$ yields the upward unit normal

$$\mathbf{n}(x,t) = -\frac{(-\nabla' \eta(x',t), 1)}{\sqrt{1 + |\nabla' \eta(x',t)|^2}}.$$

In this case $\Gamma_t - \Gamma_*$ with Γ_* a plane $x_N = 0$ can be represented in the more explicit form

$$\Gamma_t - \Gamma_* = \|\eta\|_X := \Big(\int_\Sigma \frac{|\nabla' \eta|^2}{\sqrt{1 + |\nabla' \eta|^2}} \, dx' \Big)^{1/2} < \infty,$$

where X denotes the subspace of functions $\eta \in H^1(\Sigma)$ satisfying $\|\eta\|_X < \infty$. In our nonlinear stability we control for all time the L^2 norm of the velocity and the quantity $\|\eta\|_X$.

The goal is achieved by using a definition of perturbation different from the one usually adopted that has been recently proposed by ourselves.

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MS86

Loss of Control of Motions from Initial Data for Pending Capillary Liquid

We consider a horizontal layer of heavy viscous fluid bounded above by a rigid surface and below by a free surface. We reduce the study of nonlinear instability into the sign of initial energy of perturbations. In nonlinear phenomena, a solution may loose its control from initial data for large data, even though a linearly stable state. We construct a solution such that though linearly stable, it is not controlled by initial data when these data are larger than an computable constant. It is a joint work with U. Massari (Ferrara, Italy) and M. Padula (Ferrara, Italy).

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MS86

Bifurcation Theorems for Free Surface Problems

Abstract not available at time of publication.

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MS87

Strong Solution of Compressible Nematic Liquid Crystal Flows

We prove local existence of unique strong solutions of compressible nematic liquid crystal flows in a domain of R^3, provided that an initial vacuum may exist. We then prove a blow-up criterion for the local strong solution at finite time in terms of $\|\rho\|_{L^\infty_t L^\infty_x}$ and $\|\nabla d\|_{L^3_t L^\infty_x}$. We also establish a blow-up criterion in terms of the temporal integral of both the maximum norm of the deformation tensor of velocity gradient and the square of $\|\nabla d\|_{L^\infty_x}$.

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MS87

Poisson-Nernst-Planck (PNP) Equations for Ion Transport

Understanding ion transport is crucial in the study of many physical and biological problems, such as semiconductors, electro-kinetic fluids, transport of electrochemical systems and ion channels in cell membranes. One of the fundamental models for the ionic transport is the time dependent coupled diffusion-convection equations, the Poisson-Nernst-Planck (PNP) system. The PNP system consists of the electro-static Poisson and Nernst-Planck equations describing electro-diffusion and electrophoresis. In this lecture, Ill introduce our recent results on the equilibrium of the PNP system and the linear stability problem.

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MS87

Existence of Globally Weak Solutions to the Flow of Compressible Liquid Crystals System

We study a simplified system for the compressible fluid of Nematic Liquid Crystals in a bounded domain in three Euclidean space and prove the global existence of the finite energy weak solutions.

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MS87

Motion of vortices in the Landau-Lifschitz-Gilbert equation

A simplified model for the energy of the magnetization of a thin ferromagnetic film gives rise to a version of the theory of Ginzburg-Landau vortices for sphere-valued maps. In particular we have the development of vortices as a certain parameter tends to 0. The dynamics of the magnetization is ruled by the Landau-Lifshitz-Gilbert equation, which combines characteristic properties of a nonlinear Schrodinger equation and a gradient flow. I will discuss the motion of the vortex centers under this evolution equation.

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MS87

On Global Solutions to Flows of Liquid Crystals

The three-dimensional equations for the incompressible and compressible flows of liquid crystals are considered. The existence, large-time behavior, and incompressible limit of global strong and weak solution are discussed.

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MS88

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MS88

Two Phase Flow in Porous Media: the Saffman-Taylor Instability Revisited

Plane waves for two phase flow in a porous medium are modeled by the one-dimensional Buckley-Leverett equation, a *scalar* conservation law. We analyze linearized stability of sharp planar interfaces to two-dimensional perturbations, which involves a *system* of PDE. Numerical simulations of the full nonlinear system, including dissipation, illustrate the analytical results. We also discuss a modified Buckley-Leverett equation, in which the capillary pressure is rate-dependent, thereby adding a BBM-type dispersive term. This equation sustains undercompressive planar waves, but they are all unstable to two-dimensional perturbations.

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MS88

Rate of Convergence for Vanishing Viscosity Approximations to Hyperbolic Balance Laws

Results on the rate of convergence for vanishing viscosity approximations to hyperbolic balance laws are presented. The systems under consideration are strictly hyperbolic and genuinely nonlinear with a source term satisfying a special mechanism that induces dissipation. The proof relies on error estimates that measure the interaction of waves. Shock waves are treated by monitoring the evolution of suitable Lyapunov functionals, whereas interactions involving rarefaction waves are accomodated by employing a sharp decay estimate.

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MS88

GlobalSsolutions to Variational Nonlinear Wave Systems Modelling Nematic Liquid Crystals

Abstract not available at time of publication.

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MS89

An Envelope Approximation of Out-of-Plane Gap Solitons in 2D Photonic Crystals

We consider the nonlinear Maxwell equations for 2D Kerr nonlinear photonic crystals for fields propagating out of the plane of periodicity, cf e.g. photonic crystal fibers. Similarly to [Dohnal, Uecker, arXiv:0810.4499] we show that gap solitons in the vicinity of gap edges are approximated via modulation equations, so called coupled mode equations (CMEs), the coefficients of which are determined by the linear band structure of the Maxwell system. We numerically compute the band structure and the CME coefficients for a cylindrical photonic crystal geometry with a hexagonal Wigner-Seitz cell.

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MS89

Modulation Equations for Two Gravity Water-waves of Finite Depth

We consider the 3D gravity water-wave problem of finite depth, derive the leading and next-to-leading order macroscopic equations of hyperbolic scaling for small amplitudes of the surface elevation for a system of two arbitrary carrier waves, and discuss their rigorous justification.

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MS89

Nearly Finite-Dimensional Dynamics in Optical Waveguides

We investigate the dynamics of small-amplitude solutions to NLS with a potential supporting three eigenfunctions whose initial conditions are a superposition of the eigenmodes. We demonstrate that solutions are well-approximated by an ODE derived using a Galerkin truncation, and that the finite-dimensional dynamics are interesting. The ODE has standing waves, relative periodic orbits, heteroclinic connections, and apparent chaos. Its normal form remains poorly understood. We discuss proposed physical experiments in an optical waveguide.

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MS89

Linearized Backlund Transform as a tool to prove stability

Recently, the linearized backlund transform has been used to prove stability of solitons and multi-soliton solutions in several completely integrable systems. We will discuss this method for the Toda lattice and the Sine-Gordon equation.

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MS90

A Result on Homogenization of Fronts in Highly Heterogeneous Media

I will consider the evolution by mean curvature in a heterogeneous medium, modeled by a periodic forcing term. I will discuss two related problems: the existence of a homogenization limit, when the dimension of the periodicity cell tends to zero, and the long time behaviour of the evolution, in particular the existence of travelling waves solutions.

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MS90

Pinning and Depinning of Interfaces in Random Media

We consider a parabolic model for the evolution of an interface in random medium. The local velocity of the interface is governed by line tension and a competition between a constant external driving force $F > 0$ and a heterogeneous random field $f(x, y, \omega)$, which describes the interaction of the interface with its environment. To be precise, let $(\Omega, \mathbf{F}, \mathbf{P})$ be a probability space, $\omega \in \Omega$. We consider the evolution equation

$$\partial_t u(x,t,\omega) = \Delta u(x,t,\omega) - f(x, u(x,t,\omega), \omega) + F$$

with zero initial condition. The random field $f > 0$ has the form of localized smooth obstacles of random strength. In particular, we are interested in the macroscopic, homogenized behavior of solutions to the evolution equation and their dependence on F. We prove that, under some assumptions on f, we have existence of a non-negative stationary solution for F small enough. This means that all solutions to the evolution equation become stuck if the driving force is not sufficiently large. The proof relies on a percolation argument. Given stronger assumptions on f, but still without a uniform bound on the obstacle strength, we also show that for large enough F the interface will propagate with a finite velocity. The two results combined show the emergence of a rate-independent hysteresis in systems subject to a viscous microscopic evolution law through the interaction with a random environment.

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MS90

Front Propagation in Stratified Media: A Variational Approach

We prove, under generic assumptions, that the special variational traveling wave that minimizes the exponentially weighted Ginzburg-Landau functional associated with scalar reaction-diffusion equations in infinite cylinders is the long-time attractor for the solutions of the initial value problems with front-like initial data. The convergence to this traveling wave is exponentially fast. The obtained result is mainly a consequence of the gradient flow structure of the considered equation in the exponentially weighted spaces and does not depend on the precise details of the problem. It strengthens our earlier generic propagation and selection result for "pushed' fronts.

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MS90

Stochastic Allen-Cahn Equation and Mean Curvature Flow

In this talk we review some recent results on perturbation of the Allen-Cahn equation by a random forcing. It is

well known that the deterministic Allen-Cahn equation approximates an evolution of phase indicator functions. The phase boundaries perform a motion by mean curvature. We investigate if this behaviour is stable under random perturbations. To be more precise, we want to know if it is true that a stochastically perturbed Allen-Cahn equation converges to a stochastically perturbed mean curvature flow. We show that this is true - at least for short times - in the simplest possible case, where the forcing is the approximation of a one-dimensional time dependent white noise. Then we study a more complicated forcing by a stochastic transport-type term. We obtain compactness and regularity results. The limiting evolution will also be discussed.

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MS91

Scattering and Estimation from Cross Correlations

We will analyze the waves transmitted and reflected by a random mediumin the case in which the medium has rapid random fluctuations. This involves deriving a white noise approximation for the wave field. We will show how the second-order statistics of the wave can be determined by this white noise approximation in the paraxial regime and be used for imaging.

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MS91

Passive Sensor Imaging using Cross-correlations of Noisy Signals

We consider here the problem of imaging using passive incoherent recordings due to ambient noise sources. The first step towards imaging in this configuration is the computation of the cross-correlations of the recorded signals. These cross-correlations are computed between pairs of sensors (receivers) and contain very important information about the background medium. They can be used, for example, to compute the travel time between sensors or even the Green's function from one sensor to the other. Our aim is to use these cross-correlations in order to image reflectors embedded in clutter. To do so we will use coherent imaging methods, such as travel time migration and coherent interferometry (CINT).

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MS91

Thermoacoustic and Photoacoustic Tomography

Abstract not available at time of publication.

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MS91

Title Not Available at Time of Publication

Abstract not available at time of publication.

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MS92

Finite Element Discretization of the Navier-Stokes Equations with Mixed Boundary Conditions

We consider a variational formulation of the three-dimensional NavierStokes equations with mixed boundary conditions and prove that the variational problem admits a solution provided that the domain satis?es a suitable regularity assumption. Next, we propose a ?nite element discretization relying on the Galerkin method and establish a priori and a posteriori error estimates.

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MS92

Stabilized Finite Element Solvers of Incompressible Flow Equations: Modeling of Stabilization Coefficients via Kinetic Energy

The turbulent kinetic energy (TKE) plays a major role in standard tubulence models. In particular, Variational Multi-scale (VMS) models may be used as turbulence models. This includes on one hand two-grids models, that include modeling of eddy diffusion that acts on the equation of the small resolved scales. On another hand it includes Orthogonal Sub-grid Scale methods, that provide a with full modeling of large-small scale interactions, without the need of eddy diffusion modeling. All these models require stabilization parameters. This talk analyzes wether the use of TKE may improve VMS models. We derive a modeling of stabilization parameters depending of the TKE. The

TKE is obtained as the solution of a modeled equation. We prove that this equation is well posed in $W^{1,q}$ norm, for $1 < q < d'$ (d is the space dimension), and that it tends to zero in this norm as the turbulent perturbation tends to zero in H^1 norm. In this sense we are considering LES models. We present some numerical tests that fully confirm these results, and also seem to indicate that the TKE equation is not well posed in H^1 norm. We finally present some results for lid-driven cavity flow that support the basic modeling hypothesis, that gives a functional structure for the perturbation in terms of the residual associated to the large resolved scales. We also show that TKE may be used as a good error indicator.

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MS92

Asympotic Analysis of the Approximate Deconvolution Models to the Mean Navier Stokes Equations

We consider a 3D Approximate Deconvolution Model (ADM) which belongs to the class of Large Eddy Simulation (LES) models. We aim at proving that the solution of the ADM converges towards a dissipative solution of the mean Navier-Stokes Equations, for periodic boundary conditions. The convolution filter we first consider is the Helmholtz filter. We next consider generalized convolution filters for which the convergence property still holds.

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MS92

On Large Data Analysis of Kolmogorov's Two Equation Model of Turbulence

Kolmogorov seems to be the first who recognized (in 1941) that a two equation model of turbulence might be appropriate to turbulent flow prediction. We present the results (joint work with M. Bulicek concerning long-time and large-data existence of weak solution to three-dimensional flows described by this Kolmogorov's two equation model of turbulence. Similar results (joint work with M. Bulicekek and R. Lewandowski associated with one equation model of turbulence (for turbulence kinetic energy) will be presented as well.

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MS93

A Mimetic Scheme to Solve Poisson's Equation ia a 3-d Curvilinear Mesh

The performance and accuracy of the Castillo-Grone Mimetic has already been shown in many fields. There have been a number of studies in both one-dimensional and two-dimensional mostly in a uniform mesh; however, there are some publication showing the same performance in a non-uniform mesh. In this talk, we will discuss the performance of a scheme based on the Castillo-Grone mimetic operators in a 3-D fully curvilinear mesh by solving a Poissons equation. Poissons equation arises in many fields including non-hydrostatic simulation of Navier-Stokes equations. Solving Poissons equation in a 3-D fully curvilinear coordinate system is a vital step in these types of simulations. We will discuss both the accuracy and the performance of a difference scheme based on the Castillo-Grone mimetic operators in solving the Poissons equation in a fully 3-D curvilinear mesh

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MS93

A Mimetic Difference Method for Maxwell Equations on a Non-uniform Logically Rectangular Mesh

A Mimetic formulation of Maxwell equations and their properties in two and three dimensional on non-uniform structured grids are developed. This formulation is an extension of the Castillo-Grone mimetic operators, for the 2-D curl operator on a uniform mesh. This mimetic numerical method produces approximations of fourth order both at the grid boundary and in the grid's interior

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MS93

A Distributed Mimetic Approach to Simulating Water-rock Interaction Following CO2 Injection in Sedimentary Basinsme

Risk estimation of short- and long-term geologic storage of CO2 can only be addressed through numerical modeling and simulation. In this paper we employ a novel mimetic numerical method to model the short-term (10-100 year) effects of CO2 injection in a sandstone formation modeled after the Oligocene Frio Formation, a regional brine reservoir along the U.S. Gulf Coast. Mimetic numerical methods solve a discrete analog of a continuum problem. Applied to geologic carbon sequestration, we employ a finite-difference mimetic method to solve an elemental conservation of solute species mass equation that governs solute transport in deep brine water residing in a permeable sandstone formation, subjected to the injection of supercritical phase CO2. Our novel implementation has been developed for use on many-core clusters and uses the distributed SuperLU library developed at Lawrence Berkeley National Laboratory for solving large sparse nonsymmetic systems constructed to compute solute activities during each time step. We demonstrate that a mimetic approach to the numerical modeling of water-rock interaction yields solutions that achieve a comparably higher order approximation at, or near, the boundary of a defined reservoir.

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MS93

A Numerical Study of a Mimetic Scheme for the Unsteady Heat Equation

A new mimetic scheme for the unsteady heat equation is presented. It combines the Castillo-Grone mimetic discretizations for gradient and divergence operators in space with a Crank-Nicolson approximation in time. A comparative numerical study against standard finite difference shows that the proposed scheme achieves higher convergence rates, better approximations, and it does not require ghost points in its formulation.

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MS94

Experiments on Water Waves in Finite, Variable Depth

We report on experiments on surface-gravity waves on water of finite and variable depth using the Davey-Stewartson equation in one propagation direction as a mathematical framework.

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MS94

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

The water wave equations govern the movement of a large body of water (e.g., the ocean), and among the many motions permitted, the traveling wave solutions are of great interest due to their ability to transport energy and momentum over great distances in the ocean. Of course not all of these traveling waveforms are dynamically stable and it is of crucial importance to identify those that are as these will be the only ones observed in practice. In a recent publication the author endeavored upon a study of the spectral stability of periodic traveling water waves on a two-dimensional (one vertical and one horizontal) fluid. The author used the fact that traveling waves come in analytic branches to show that, in the case of simple eigenvalues, the spectral data can also be parametrized analytically. With this point of view, the author followed the "motion" of the spectrum in the complex plane as a wave height/steepness parameter was increased, deducing (weak) spectral stability provided the parameter was sufficiently small (e.g., up to divergence of the expansions). In this talk we expand these results to eigenvalues of higher multiplicity (resonance), in particular the important case of multiplicity two where, again, we can deduce weak spectral stability. Time permitting, we will present numerical results and the details of eigenvalues of multiplicity three (e.g. Benjamin-Feir) and higher.

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MS94

Water Waves: Reconstructing the Surface Elevation from Pressure Data

A new method is proposed to recover the water-wave surface elevation from pressure data obtained at any depth below the fluid surface. The new method requires the numerical solution of a nonlocal nonlinear equation relating the pressure and the surface elevation which is obtained from the Euler formulation of the water-wave problem without approximation. This new approach is compared with other approaches currently used in field observations.

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MS94

Inverse Problems in the Theory of Water Waves

The problem of surface water waves has been formulated in several different but equivalent ways, e.g. Zakharov's Hamiltonian formulation, the Dirichlet-to-Neumann operator formulation of Craig and Sulem and the recent Ablowitz-Fokas-Musslimani formulation. In this talk I shall describe how certain inverse problems in water waves may be approached by combining results from the various formulations.

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MS94

Bifurcation and Resonance in Standing Water Waves

We develop a trust-region shooting algorithm for solving two-point boundary value problems governed by nonlinear PDE. We use our method to compute families of time-periodic solutions of the gravity-driven water wave in two and three dimensions, focusing on questions of stability, resonance and the effect of small divisors. We also an-

swer negatively a long-standing conjecture of Penney and Price about the existence of a limiting standing wave of maximum amplitude that forms a sharp, 90 degree interior crest angle each time the fluid comes to rest.

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MS95

Asymptotic Behavior for the Aggregation Equation with Diffusion

We consider the equation $\partial_t \rho = \nabla \cdot ((\nabla W * \rho)\rho) + \Delta\rho$, a diffusive equation with a nonlinear and nonlocal term given by a self-interaction through a potential W. We will give well-posedness results and study its asymptotic behavior. If W satisfies some suitable bounds, one can prove that the behavior is dominated by diffusion, this is, solutions behave for large times essentially like those of the heat equation. Precise estimates on rates of convergence to the fundamental solution to the heat equation can be given by using entropy methods.

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MS95

Regularity of Solutions to the Liquid Crystals Systems in R^2 and R^3

We study the regularity and uniqueness of solutions to systems of nematic liquid crystals with non-constant density. We establish that, in R^2, the global regularity with general data; in R^3, the global regularity with small initial data and a local (short time) regularity with large data. In addition, with more smoothness assumption on initial data, we obtain the uniqueness both for dimension 2 and 3 cases.

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MS95

Vortex Sheets in Exterior Domains and Kelvin's Circulation Theorem

We consider incompressible ideal 2D flow in the exterior of N obstacles with vortex sheet regularity, i.e., the vorticity is assumed to be a bounded Radon measure in H^{-1}. We assume that the vorticity is of distinguished sign. We are concerned with the conservation of circulation around individual boundary components, which holds for smooth flows. We establish an analogue of this conservation law for weak solutions with vortex sheet regularity.

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MS95

Construction of Almost Sharp Fronts for the Surface Quasi-geostrophic Equation

I will describe recent work with Charles Fefferman on a construction of families of analytic almost-sharp fronts for SQG. These are special solutions of SQG which have a very sharp transition in a very thin layer. One of the main difficulties of the construction is the fact that there is no formal limit for the family of equations. I will show how to overcome this difficulty, linking the result to joint work with C. Fefferman and Kevin Luli on the existence of a "spine" for almost-sharp fronts. This is a curve, defined for every time slice by a measure-theoretic construction, that describes the evolution of the almost-sharp front.

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MS96

The Pattern of Multiple Rings from Morphogenesis in Development

Under certain conditions the problem of morphogenesis in development and the problem of morphology in block copolymers may be reduced to one geometric problem. In two dimensions two new types of solutions are found. The first type of solution is a disconnected set of many components, each of which is close to a ring. The sizes and locations of the rings are precisely determined from the parameters and the domain shape of the problem. The solution of the second type has a coexistence pattern. Each

component of the solution is either close to a ring or to a round disc. The first-type solutions are stable for certain parameter values but unstable for other values; the second-type solutions are always unstable. In both cases one establishes the equal area condition: the components in a solution all have asymptotically the same area.

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MS96

Existence of Multiple Spike Stationary Patterns in a Chemotaxis Model with Weak Saturation

We are concerned with a multiple boundary spike solution to the steady-state problem of a chemotaxis system: $P_t = \nabla \cdot \left(P\nabla(\log \frac{P}{\Phi(W)})\right)$, $W_t = \epsilon^2 \Delta W + F(P,W)$, in $\Omega \times (0, \infty)$, under the homogeneous Neumann boundary condition, where $\Omega \subset \mathbf{R}^N$ is a bounded domain with smooth boundary, $P(x,t)$ is a population density, $W(x,t)$ is a density of chemotaxis substance. We assume that $\Phi(W) = W^p$, $p > 1$, and we are interested in the cases of $F(P,W) = F_1(P,W) = -W + \frac{PW^q}{\alpha+\gamma W^q}$ and $F(P,W) = F_2(P,W) = -W + \frac{P}{1+kP}$ with $q > 0, \alpha, \gamma, k \geq 0$, which has a saturating growth. In this talk, we assume that Ω is symmetric with respect to each hyperplane $\{x_1 = 0\}, \cdots, \{x_{N-1} = 0\}$. For two classes of $F(P,W)$ above with saturation effect, we show the existence of multiple boundary spike stationary patterns on Ω under a weak saturation effect on parameters α, γ and k. This talk is based on a joint work with Dr. K. Morimoto.

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MS96

Delay Gierer-Meinhart Systems in the Self-organisation of Cells

Modelling investigations of cellular systems typically neglect the influence of gene expression on such dynamics, even though transcription and translation are observed to be important in morphogenetic systems. We formulate and explore two mathematical models of extracellur morphogen dynamics based on Gierer-Meinhardt systems, in which gene expression time delays are incorporated by the direct application of the mass action law via sub-cellular dynamics.

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MS96

Singularly Perturbed Nonlinear Neumann Problems under Optimal Conditions for the Nonlinearity

Let Ω be a bounded domain in R^N with the boundary $\partial\Omega \in C^3$. We consider the following singularly perturbed nonlinear elliptic problem on Ω,

$$\varepsilon^2 \Delta v - v + f(v) = 0, \quad v > 0 \quad \text{on} \quad \Omega, \quad \frac{\partial v}{\partial \nu} = 0 \quad \text{on} \quad \partial\Omega,$$

where ν is the exterior normal to $\partial\Omega$ and the nonlinearity f is of subcritical growth. Under Berestycki and Lions conditions for $f \in C^1(R)$, which turns out to be rather strong regularity, it has been known that there exists a solution v_ε of the above problem which exhibits a spike layer near a local maximum point of the mean curvature H on $\partial\Omega$ as $\varepsilon \to 0$ for $N \geq 3$. In this paper, we extend to the result under Berestycki and Lions conditions for $f \in C^0(R)$ (almost optimal condition) for $N \geq 2$.

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MS96

Toroidal Solutions to a Pattern Formation Problem of Mean Curvature and Newtonian Potential

Pattern formation problems arise in many physical and biological systems as orderly outcomes of self-organization principles. Examples include animal coats, skin pigmentation, and morphological phases in block copolymers. Recent advances in singular perturbation theory and asymptotic analysis have made it possible to study these problems rigorously. In this talk I will discuss a successful approach in the construction of various patterns as solutions to some well known PDE and geometric problems: how a single piece of structure built on the entire space can be used as an ansatz to produce a near periodic pattern on a bounded domain. We start with the simple disc ansatz to show how the spot pattern in morphogenesis and the cylindrical phase in diblock copolymers can be mathematically explained, and end with the torus ansatz for the toroidal supramolecule assemblies recently discovered in block copolymers.

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MS97

Nonlinear Maximum Pinciples for Lnear Nnlocal Oerators and Aplications

Nonlocal dissipative operators have "shape-dependent" maximum principles. I will explain these and provide ideas of proofs. These maximum principles are nonlinear, robust and rather useful. I will give some examples of applications.

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MS97
Optimal Stirring for Passive Scalar Mixing

We address the challenge of optimal incompressible stirring to mix an initially inhomogeneous distribution of passive tracers. As a measure for mixing we adopt the H^{-1} norm of the scalar fluctuation field. This 'mix-norm' is equivalent to (the square root of) the variance of a low-pass filtered image of the tracer concentration field, and is a useful gauge even in the absence of molecular diffusion. This mix-norm's vanishing as time progresses is evidence of the stirring flow's mixing property in the sense of ergodic theory. For the case of a periodic spatial domain with a prescribed instantaneous energy or power budget for the stirring, we determine the flow field that instantaneously maximizes the decay of the mix-norm, i.e., the instantaneous optimal stirring — when such a flow exists. When no such 'steepest descent' stirring exists, we determine the flow that maximizes that rate of increase of the rate of decrease of the norm. This local-in-time stirring strategy is implemented computationally on a benchmark problem and compared to an optimal control approach utilizing a restricted set of flows. This is joint work with Zhi Lin, Evelyn Lunasin, and Jean-Luc Thiffeault.

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MS97
Geodesic Equations on the Contactomorphism Group

A contact form on a Riemannian manifold of dimension $2n+1$ is a 1-form α such that $\alpha \wedge (d\alpha)^n$ is nowhere zero; the basic example is a left-invariant 1-form on the group of unit quaternions which is closely related to the Hopf fibration of S^3 over S^2. Contact forms are generally viewed as the odd-dimensional analogue of symplectic forms. Given a contact form we can consider the groups of diffeomorphisms either preserving the contact form exactly (the group of strict contactomorphisms or quantomorphisms), or preserving the contact form up to a nowhere zero function (the contactomorphism group). It is a well-known result of Arnold that the geodesic equation of the L^2 metric on the group of volume-preserving diffeomorphisms is the Euler equation of ideal fluid mechanics. We discuss the geodesic equation arising on both of the contactomorphism groups, including smoothness, local and global existence, and stability properties. The geodesic equation for strict contactomorphisms is related to the Euler equation with symmetry (e.g., the axisymmetric Euler equation without swirl), while the geodesic equation for non-strict contactomorphisms has many properties in common with the Camassa-Holm equation (and reduces to it when $n = 0$).

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MS97
Bounds on Heat Transport for Fixed Flux Thermal Boundary Conditions at Infinite Prandtl Number

Convection enhances the transport of heat in a fluid layer. In Rayleigh-Benard convection this enhancement is measured by the Nusselt number Nu. Of intense interest is the functional dependence of the Nusselt number on the material parameters of the system; the ratio of viscosity to thermal diffusivity given by the Prandtl number Pr, the geometry usually indicated by an aspect ratio, and the driving force as described by the dimensionless Rayleigh number Ra. When $Ra \to \infty$ (in the presence of turbulence), it is generally agreed that $Nu \sim Ra^\gamma$. The dependence of γ on the velocity boundary conditions for the flow (i.e., stress-free or no-slip) and the temperature boundary conditions (i.e., fixed temperature or fixed flux) is of particular interest. The focus of most prior work (experimental, numerical simulations, and analytic bounds) has been on fixed temperature, no-slip boundaries. It has been pointed out that experimentally, fixed temperature boundaries are difficult to realize. Even so, recent numerical simulations and rigorous variational bounds have indicated that changes in the thermal boundary condition do not affect γ. To complete this investigation of varying thermal boundaries, we consider the reduced infinite Pr system, and use a series of Hardy-Rellich type estimates to show that, $Nu \leq C \log(Ra)^{2/3} Ra^{1/3}$ for no-slip, fixed flux boundary conditions.

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MS97
Oscillations of Solutions to the Navier-Stokes Equations

Abstract not available at time of publication.

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MS98
The Stability of Pulses in Singularly Perturbed Reaction-diffusion Equations

In recent years, methods have been developed to study the existence and stability of pulses in singularly perturbed reaction-diffusion equations in one space dimension, in the context of a number of model problems such as the Gray-Scott and the Gierer-Meinhardt equations. Although these methods are in principle of a general nature, their applicability relies strongly on the characteristics of these models. For instance, the slow reduced spatial problem is linear in the models considered in the literature. This property is an essential ingredient of the spectral stability analysis. In this talk, we present a significantly extended method by which the Evans function associated to the general spectral problem can be decomposed into a fast and a slow component. Both components can be constructed explicitly, so that the spectrum can be determined analytically.

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MS98

On the Modulational Instability for the Benjamin-Ono Equation

I will discuss the modulational stability and instability for a class of nonlinear dispersive equations, possibly involving nonlocal dispersion operators, such as the Benjamin-Ono equation and the intermediate long wave equation. In case the equation is equipped with Hamiltonian structure and thus periodic traveling-wave solutions arise as critical points of a constrained Hamiltonian, I will explain how the traditional Evans function based approach can be related to direct Bloch wave expansions. This is joint work with Jared Bronski.

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MS98

Nonlinear Modulational Stability of Periodic Traveling Waves in a Generalized Kuramoto-Sivashinsky Equation

In this talk, we consider the stability of periodic traveling wave solutions of a generalized Kuramoto-Sivashinsky equation. In special cases it has been known since 1976 that, when subject to small localized perturbations, spectrally stable solutions of this form exist. Although numerical time-evolution studies indicate that these waves should also be nonlinearly stable to such perturbations, an analytical verification of this result has only recently been provided. Here, I will discuss this result and, if time allows, I will briefly discuss the stability of such waves to small nonlocalized perturbations asymptotic to constant shifts in phase.

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MS98

Homoclinic Solutions as Critical Points of Functionalized Energies

Abstract not available at time of publication.

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MS98

Structured Interfaces and Network Formation in the Functionalized Cahn-Hilliard Equation

We show that a binary mixture of solvent and charged polymer, as modeled by the Funcationalized Cahn-Hilliard energy, generates competing families of bilayer, pore, and micelle networks. In a mass preserving gradient flow we examine the competition between between these structures which leads to the hysteresis observed in polymer eletrolyte membrane hydration. In particular we examine the influence of the volume fraction of the competing structures on the their curvature driven flow.

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MS99

Gamma Convergence of Lawrence-Doniach Energies

We consider the Lawrence-Doniach energy functional for layered superconductors and a three-dimensional anisotropic Ginzburg-Landau energy functional. Both models have been used to describe high-temperature superconductors. We prove that as the interlayer spacing in the Lawrence-Doniach model tends to zero, the Lawrence-Doniach energy (with appropriate Josephson coefficients) Γ-converges to the three-dimensional anisotropic Ginzburg-Landau energy. We also prove compactness results which ensure that local minimizers of the Lawrence-Doniach energy converge to local minimizers of the anisotropic Ginzburg-Landau energy.

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MS99

Critical Phenomena in Keller-Segel Equations for Chemotaxis and Related Particle Models

The Keller-Segel PDEs describe chemotaxis, a phenomenon characterized by the bias of the bacterial motion according to concentration of some chemical. These equations exhibit blow-ups, a mathematical manifestation of the bacteria concentrating at the finest spatial scales. Studying these blow-ups is a challenging problem, both analytically and numerically. I will discuss some associated stochastic particle models and numerical methods which allow us to study this interesting phenomenon.

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MS99

Bifurcation Theory of Layer Undulations in Smectic A Liquid Crystals

We study the Landau-de Gennes free energy to describe the undulations instability in smectic A liquid crystals subjected to magnetic fields. If a magnetic field is applied in the direction parallel to the smectic layers, an instability occurs above a threshold magnetic field. When the magnetic field reaches this critical threshold, periodic layer undulations are observed. We study this phenomenon analytically by considering the minimizer of the second variation of the Landau-de Gennes free energy at the undeformed state and by carrying out a bifurcation analysis of the nontrivial solution curve. We prove the existence and stability of the solution to the nonlinear system of Landau-de Gennes model using bifurcation theory. We also perform numerical simulations to illustrate the results of our analysis. We also give an efficient numerical scheme for some free energy containing the second order gradient.

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MS99

Decay Rates in the Cahn Hilliard Equation

Together with Felix Otto we have given a new proof of the slow coarsening dynamics of the one-dimensional Allen-Cahn equation. The method is by way of an abstract result that captures the phenomenon of "dynamic metastability" for any gradient flow. When one tries to apply the same method to the one-dimensional Cahn-Hilliard equation, one discovers (a) that one can also prove an energy-energy-dissipation result in this setting, and (b) that this is not enough. We explain the issues and the connection to a stability problem on the real line.

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MS100

Wrinkles as a Relaxation of Compressive Stresses in Annular Thin Films

It is well known that elastic sheets loaded in tension will wrinkle, with the length scale of wrinkles tending to zero with vanishing thickness of the sheet [Cerda and Mahadevan, Phys. Rev. Lett. 90, 074302 (2003)]. We give the first mathematically rigorous analysis of such a problem. Since our methods require an explicit understanding of the underlying (convex) relaxed problem, we focus on the wrinkling of an annular sheet loaded in the radial direction [Davidovitch et al, arxiv 2010]. While our analysis is for that particular problem, our variational viewpoint should be useful more generally. Our main achievement is identification of the scaling law of the minimum energy as the thickness of the sheet tends to zero. This requires proving an upper bound and a lower bound that scale the same way. We prove both bounds first in a simplified Kirchhoff-Love setting and then in the nonlinear three-dimensional setting. To obtain the optimal upper bound, we need to adjust a naive construction (one family of wrinkles superimposed on the planar deformation) by introducing cascades of wrinkles. The lower bound is more subtle, since it must be ansatz-free.

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MS100

The Lame' Problem: A Prototypical Model for Wrinkling of Thin Sheets

Wrinkling patterns are often assumed to reflect a (supercritical) instability of a symmetric state of thin compressed sheets. The subtlety of this interpretation will be demonstrated through the Lamé geometry: annular sheet under axisymmetric tension. This elementary, yet nontrivial extension of Euler buckling, exhibits wrinkling patterns that vary markedly away from threshold. Focusing on the near-threshold and far-from-threshold limits, I will show how they emanate from distinct asymptotic expansions of Föppl-von Kármán equations.

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MS100

The Matching Property of Infinitesimal Isometries for Developable Shells

We study regularity, rigidity, density and matching properties for first order Sobolev-regular infinitesimal isometries on developable surfaces without flat regions. We prove that given enough regularity of the surface, any first order infinitesimal isometry can be matched to a higher order isometry. Our study is motivated by its applications elasticity of thin shells.

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MS100

Wrinkling of a Floating Elastic Thin Film

In this talk, I will explain the smooth cascade of wrinkles at the edge of a floating elastic thin film based on the energy scaling law point of view. This phenomena has been observed experimentally by Huang et al. This is joint work with Bob Kohn.

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MS101

Long-Time Behavior for Nonlinear Size-Structured Population Models

The evolution of a size-structured population in which individuals grow and split can be modeled by the growth-fragmentation equation. We present nonlinear versions of this equation which take into account some saturation effects of the total population on the growth or/and the death rate. The long-time behavior of the solutions is investigated by using the eigenelements of the linear growth-fragmentation operator and their dependence on parameters.

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MS101

Size-Structured Populations with Distributed States at Birth

In contrast to age-structured models in population dynamics where every individual is born at the same age 0, size-structured models allow to take into account different, i.e. distributed birth sizes. This introduces an operator that takes values in an infinite-dimensional Banach space and complicates greatly the ananlysis of questions such as asymptotic growth, existence and stability of steady states etc. In this survey, we will describe some examples of models that we recently investigated in a series of joint papers with Jozsef Farkas (University of Stirling, United Kingdom).

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MS101

Age-structured Division Equations: Unexpected Asymptotics

We present here a recent joint work with Stéphane Gaubert. The very simple age-structured division equation,

$$\begin{cases} \partial_t n + \partial_x n + K(t,x)n(t,x) = 0, \\ n(t,x=0) = 2\int_0^\infty K(t,x)n(t,x)dx, \end{cases}$$

that models the division of a cell of age x into two cells of age 0 at rate K can show unexpected complexity once we allow dependence both in age and time for this division rate. We interest ourselves especially to the effect of K on the Malthus rate λ that describes the exponential growth of the system. Link with discrete system is established when we allow this rate to take infinite values.

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MS101

Structured Population Models of Cell Differentiation and Tissue Regeneration

We introduce and analyze a general class of structured population models describing the dynamics of cell population based on cell differentiation process. The models are based on a nonlinear transport equation coupled with ordinary differential equations. Comparing the model to its discrete counterpart we address the question of the choice of the right class of models, for example discrete compartments with maturation punctuated by division events versus continuous maturation. We show that the models may exhibit different dynamics. Interestingly, the structure of steady states varies and the discrete compartmental model admits semi-trivial steady states, which do not exist in the continuous differentiation model. Finally, we present how to unify the discrete and continuous dynamics in the framework of measure-valued solutions. To obtain ODE-type quasi-stationary node points we exploit the idea of non-Lipschitz zeroes in the velocity. Since the analysis has biological motivations, we provide examples of its application in hematopoiesis and neurogenesis.

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MS102

Dynamics in a Modulation Equation for Alternans in a Cardiac Fiber

While alternans in a single cardiac cell appears through a simple period-doubling bifurcation, in extended tissue the exact nature of the bifurcation is unclear. In particular, the phase of alternans can exhibit wavelike spatial dependence, either stationary or travelling, which is known as discordant alternans. We study these phenomena in simple cardiac models through a modulation equation proposed by Echebarria-Karma. Furthermore, we find spatiotemporal chaotic behavior for some extreme parameter values, and it seems significant mathematically that chaos may occur by a different mechanism from previous observations.

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MS102

Dynamics of the Visual Cortex – The Challenges Facing Population-dynamics Models

Can classical population-dynamics methods capture the dynamics of the visual cortex? The mammalian primary visual cortex (V1) is a relatively well studied area of the brain. Many experimental phenomena, such as orientation tuning, surround suppression and background ?uctuations can be rationalized by appealing to ?ring-rate models or standard population-dynamics models. However, after investigating a simple network model of V1 which exhibits many experimentally observed phenomena including those mentioned above, we ?nd that the dynamic regime of this model exhibits many causally connected transiently correlated sub- populations of neurons. We have reason to believe that these strong transient correlations within our network are (i) biologically reasonable and consistent with recent experiments, and (ii) difficult, if not impossible, to capture by examining the ensemble-averaged dynamics of any subnetwork within our system. These investigations have led us to question the utility of most population-dynamics frameworks which are built on an ensemble- or network-averaged representation of the under- lying network dynamics.

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MS102

Spiky and Transition Layer Steady States of Chemotaxis Systems via Global Bifurcation and Helly's Compactness Theorem

The most important phenomenon about chemotaxis is the aggregation of "cells", for which we use spiky or transition layer steady states to model. We use the recent general results of Shi and Wang on global bifurcation theory to analyze several variants of the Keller-Segel model, showing that positive steady states exist if the chemotaxis coefficient is large enough; then we use Helly's compactness theorem to obtain the asymptotics of these steady states as the chemotaxis coefficient tends to infinity, showing that they are spiky or have the shape of transition layers. Compared to other methods, this one is much softer and simpler; however at this moment, the method works only in the case of 1D spatial domains.

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MS102

Folds, Canards and Shocks in Advection-reaction-diffusion Models

In this talk, we will explore nonlinear advection-reaction-diffusion (ARD) models from a dynamical systems point of view. We consider diffusion as a viscous small perturbation in the ARD model. We then identify the underlying geometry of these models which leads to the existence of travelling waves and shocks (sharp interfaces) and show how this geometric structure relates to the viscous limit of the ARD model. In particular, we will show that folded invariant manifolds and canards play an essential role in the creation and form of traveling wave patterns in ARD models. Sharp interfaces in the wave form of tactically-driven cell migration is one important area of application for our results.

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MS103

Well-posedness for Two-dimensional Steady Supersonic Euler Flows Past Lipschitz Walls

We study the L^1 well-posedness for two-dimensional steady supersonic Euler flows past two Lipschitz walls whose boundary slope function has small total variation, when the total variation of the incoming flow is small. We have obtained the existence of solutions in BV when the incoming flow has small total variation by the wave front tracking method and then established the L^1 stability of the solutions with respect to the incoming flows. To do this, we have carefully incorporated the nonlinear waves generated by the wall boundaries to develop a Lyapunov functional between two solutions containing strong vortex sheets and prove that the functional decreases in the flow direction, establishing the L^1 stability and the uniqueness of solutions by the wave front tracking method. The uniqueness of solutions in a boarder class, the class of viscosity solutions, is also obtained. This is joint work with Gui-Qiang G. Chen.

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MS103

Time-Periodic Solutions for the Euler Equations

I will report on recent progress Blake Temple and I have made towards proving the existence of time-periodic shock-free solutions of the compressible Euler equations. I shall briefly recall our discovery of the simplest possible structure of such solutions, and the corresponding linearized solutions. I shall then focus on the perturbation of these linearized solutions to the fully nonlinear problem in the resonant case. We give a complete and explicit description of the kernel of the linearized operator, which has a beautiful and unexpected resonant structure. We then analyze a generic perturbation of the linearized operator, and show that genuine nonlinearity breaks the resonances. Finally, we discuss a Nash-Moser iteration which we expect will complete the proof that our linearized periodic solutions perturb to the fully nonlinear Euler equations.

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MS103

Incompressible Euler Equation from a Lagrangian Point of View and Unstable Manifolds

We outline the framework of the Euler equation as Lagrangian systems on infinite dimensional manifolds for both the fixed and free boundary cases. In particular in the former case, we prove that exponentially unstable steady states admit smooth local unstable manifolds. This in turn shows the nonlinear instability in the sense that small H^k perturbations can lead to L^2 derivation of the solutions.

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MS103

Global Low Regularity Solutions of Quasi-linear Wave Equations

In this talk we present joint work with Zhen Lei on the global existence and uniqueness of the low regularity solutions to the Cauchy problem of quasi-linear wave equations with radial symmetric initial data in three space dimensions. The results are based on the end-point Strichartz estimate together with the characteristic method.

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MS104

Weak Neumann implies Stokes

Let Ω be a domain with sufficiently smooth boundary. We show that the Stokes operater generates an analytic semigroup on $L^p(\Omega)$ provided the Helmholtz decomposition exists. In this case, the Stokes operator also satisfies maximal regularity estimates. Co-authors: Horst Heck, Matthias Hieber, Okihiro Sawada

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MS104

Global and Almost Global Solutions for the Navier-Stokes Equations in Besov Spaces and Triebel-Lizorkin

We consider the existence of the global and almost global solutions for the Navier- Stokes equations in the spaces which have scaling invariant properties to the equations, where almost global solutions are solutions which existence time is bounded below by the exponential order of the norms of initial data. On the global solutions, we study in the space of all functions of bounded mean oscillation using the Triebel- Lizorkin spaces. The existence of the almost global solutions are also studied in the larger function spaces than those for the global solutions.

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MS104

Long time Solvability of Equations in Geophysical Fluid Dynamics

In the talk, we investigate large time existence of solutions of the Navier-Stokes equations with Coriolis and/or stratification effects. We also mention an incompressible forced two-dimensional flow on a beta plane. In 1996, Kimura and Herring examined numerical simulations to show a stabilizing effect due to the stratification. They observed scattered two-dimensional pancake-shaped vortex patches lying almost in the horizontal plane. One of our result is a mathematical justification of the presence of such two-dimensional pancakes.

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MS105

Variational and Wavelet Frame Based Models for Medical Imaging and Image Analysis

In this talk, I will start with a short review of some variational models and wavelet frame based models for image restoration problems. Then I will discuss connections between one of the wavelet frame based model and a general variational model. In a nutshell, we show that when image resolution goes to infinite, the energy functional of the wavelet frame based model Gamma-converges to that of the variational model. Such connection not only grants geometric interpretations to the wavelet frame based model, but also extends the scope of applications of wavelet frames. In the final part of the talk, I will focus on the applications of variational and wavelet frame based models in x-ray based CT image reconstruction, including 3D/4D cone beam CT reconstruction, CT reconstruction with Radon domain inpainting, and color CT reconstruction and tissue classifications.

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MS105

Image Enhancement via Forward-backward Diffusion

We propose a naive PDE model of Perona-Malik type for image restoration, applicable for both image denoising and deblurring. Our proposed model uses the notion of Young measure valued solutions, which turns out to be well-posed and does great work for image denoising and deblurring. We can control the diffusivity in the solutions which will smooth out noise and then sharpen the edges for better recovery.

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MS105

A Ridge and Corner Preserving Model for Surface Restoration

One challenge in surface restoration is to design a surface diffusion preserving ridges and sharp corners. In this talk, I will present a new surface restoration model based on the observation that the surface implicit representations are continuous functions with discontinuities of the first order derivatives at ridges and sharp corners. The proposed model of vectorial total variation on the derivatives is a fourth order and convex problem. We further utilize the augmented Lagrangian method to efficiently compute the optimizer. Moreover, we also include the theoretical convergence analysis. To demonstrate the efficiency and robustness of the proposed method, we illustrate our experimental results on several different examples and also conduct comparison with mean curvature flow method and nonlocal mean method.

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MS105

Combining Event Data and Spatial Images in Variational Approaches to Density Estimation

We wish to produce a probability density estimate from discrete event data to model the relative probability of events occurring in a region. Common methods do not incorporate geographical information and could have non-negligible portions of the density's support in unrealistic locations. We propose Maximum Penalized Likelihood Estimation methods based on TV and H^1 regularizers that use spatial data to obtain more geographically accurate density estimates. We apply this method to residential burglary data.

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MS106
Quadratic systems and Airy functions

We construct exact wave functions for the most general variable quadratic Hamiltonians in terms of solutions of certain Ermakov and Riccati-type systems. Applications to a macroscopic oscillator in Bose-Einstein condensation are discussed. We solve a Schrodinger equation in terms of Airy functions and use it to solve a quantum parametric oscillator. We consider a soliton-like solution to the equation

$$\frac{\partial \psi}{\partial t} + \frac{1}{4}\frac{\partial^2 \psi}{\partial x^2} + tx^2\psi = h(t)|\psi|^2\psi \tag{2}$$

http://arxiv.org/abs/1102.5119
http://arxiv.org/abs/0903.3608

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MS106
Exact Wave Functions for Generalized Harmonic Oscillators

We construct exact wave functions for the most general variable quadratic Hamiltonians in terms of solutions of certain Ermakov and Riccati-type systems. Applications to a macroscopic oscillator in Bose-Einstein condensation are discussed. For more information, see: http://arxiv.org/abs/1102.5119

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MS106
Soliton-like Solutions for Nonlinear Schroedinger Equation with Variable Quadratic Hamiltonians

We will discuss applications of separation of variables in the study of linear and nonlinear Schrdinger equations with quadratic time-dependent Hamiltonians. In the latter we construct soliton-like solutions for certain choices of the coefficients, including important examples such as bright and dark solitons and Jacobi elliptic and second Painlev transcendental solutions, which are important for current research in nonlinear optics and Bose–Einstein condensation. Also we show an example of existence of L^8 finite time blowup for subcritical NLS. In the linear case we are able to construct the fundamental solution explicitly. We will give several examples inspired from solvable cases of the Riccati equation and emphasize an example envolving Airy functions. A large part of the results presented have been done in joint work with Sergei K. Suslov.

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MS106
On Integrability of Nonautonomous Nonlinear Schroedinger Equations

We show, in general, how to transform the nonautonomous nonlinear Schroedinger equation with quadratic Hamiltonians into the standard autonomous form that is completely integrable by the familiar inverse scattering method in nonlinear science. Derivation of the corresponding equivalent nonisospectral Lax pair is outlined. A few simple integrable systems are discussed. http://arxiv.org/abs/1012.3661

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MS106
The Riccati System and Diffusion-type Equations

We discuss a method of constructing solution of the initial value problem for diffusion- type equations in terms of solutions of certain Riccati-type systems. A nonautonomous Burgers-type equation is also considered. Examples include the Fokker-Planck equation in physics, the Black-Scholes equation and the Hull-White model in finance.

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MS107
The Grazing Collision Limit of the Inelastic Kac Model

This talk is devoted to the grazing collision limit of the inelastic Kac model introduced in [Pulvirenti-Toscani, Asymptotic properties of the inelastic Kac model, J. Statist. Phys. 2004] when the equilibrium distribution function is a heavy-tailed Levy-type distribution with infinite variance. We prove that solutions in an appropriate domain of attraction of the equilibrium distribution converge to solutions of a Fokker-Planck equation with a fractional diffusion operator.

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MS107

Title Not Available at Time of Publication

Abstract not available at time of publication.

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MS107

On the Doi Model for the Suspension of Rod-Like Molecules

The Doi model for the suspensions of rod-like molecules in a dilute regime describes the interaction between the orientation of rod-like polymer molecules on the microscopic scale and the macroscopic properties of the fluid in which these molecules are contained (cf. Doi and Edwards [10]). The orientation distribution of the rods on the microscopic level is described by a Fokker-Planck-type equation on the sphere, while the fluid flow is given by the Navier-Stokes equations, which are now enhanced by an additional macroscopic stress œ reflecting the orientation of the rods on the molecular level. Prescribing arbitrarily the initial velocity and the initial orientation distribution in suitable spaces we establish the global-in-time existence of a weak solution to our model defined on a bounded domain in the three dimensional space. The proof relies on a quasi-compressible approximation of the pressure, the construction of a sequence of approximate solutions and the establishment of compactness.

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MS108

The EBV algorithm: Now, Deal with Uncertainty!

We propose a variant of the Bred Vector (BV) algorithm, orginally introduced by Z. Toth and E. Kalnay (Bulletin of the American Meteorological Society 74:2317 2330, 1993). The algorithm can be used to assess the sensitivity of the model output to various sources of uncertainty. The new algorithm, which we call the Ensemble Bred Vector or EBV, is based on the collective dynamics (of perturbations to classical trajectories) in an essential way. It was conceived for applications to geophysical flows, as are the other similar algorithms. As such, it features some distinctive dynamical qualities compared to its brethren. I will outline the underlying mathematical ideas, and discuss some applications. Fun pictures will be on the menu, too! The talk is based on the joint work with A. L. Mazzucato, J. M. Restrepo, and G. R. Sell.

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MS108

Global Well-posedness of a 3D Stratified Reduced Rayleigh-Bénard Convection Model

The 3D Hasegawa-Mima equation arises in the study of plasma turbulence. In geophysical fluid dynamics, the equation appears as a simplified model inspired by the Rayleigh-Bénard convection model. The model is simpler than the 3D Euler equations, but the question of global existence and uniqueness of solutions is still open. Inspired by these models, we introduce and study a model of nicer mathematical structure and establish a global well-posedness result in an appropriate mathematical space.

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MS108

Navier–Stokes Equations in Thin Two-layer Domains with Non-flat Boundaries

We study two-layer incompressible fluids in a thin domain whose top, bottom and interface boundaries are not flat. The fluid is subject to the Navier friction boundary condition on the top and bottom, and the periodicity condition on the sides. The interface boundary condition from the coupled atmosphere and ocean model is imposed. We prove that regular solutions exist for all time when the initial data and body force belong to large sets in relevant function spaces, as the thickness of the domain becomes small. To deal with the involved boundary conditions on surfaces of non-trivial geometry, appropriate boundary behaviors of the fluid are derived in order to obtain good linear and non-linear estimates for Navier–Stokes equations. Our approach gives a unified treatment for both the Navier and interface boundary conditions. Moreover, in case of positive friction coefficients, no zero average condition is imposed on the solutions.

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MS108

Deterministic and Stochastic Dynamics of the Primitive Equations

We discuss recent results on the primitive equations of the ocean. Starting from the deterministic long time behavior, and regularity, results on the long time existence for the stochastic primitive equations and long time behavior will be presented.

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MS109

Analyticity and Turbulence in Fluids

It is well known regular solutions of the Navier-Stokes equations (NSE) are in fact analytic in both space and time variables. The space analyticity radius is an important physical object: at this length scale, the viscous effects and the (nonlinear) inertial effects are roughly comparable. Foias and Temam introduced an effective approach to estimate space analyticity radius via the use of gevrey norms which avoids recursive estimation of higher order derivatives. Using this technique, we study the maximal space analyticity radius of solutions as a function of time via an additional ODE connected to the NSE. We show that this ODE can be solved on a maximal domain; the boundary of this domain is given by a function (of time) that is precisely the maximal analyticity radius. We then discuss some connection between the topology of the boundary of this domain and energy cascades.

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MS109

Casimir Cascades in Two-Dimensional Turbulence

The nonlinear terms of the 2D incompressible Navier-Stokes equation are well-known to conserve energy and enstrophy. In addition, they also conserve the global integral of any continuously differentiable function of the scalar vorticity field. However, the phenomenological role of these additional inviscid invariants remains unclear: Polyakov's minimal conformal field theory model indicates that high-order Casimir invariants cascade to large scales, while Eyink suggests that they might instead cascade to small scales. Numerical investigations of this problem are hampered by the fact that pseudospectral simulations, which necessarily truncate the wavenumber domain, do not exactly conserve global integrals of arbitrary powers of the vorticity. Nevertheless, well-resolved numerical simulations can be used to demonstrate that the fourth power of the vorticity cascades to small scales. Inertial-range pumping of this quantity by the large-scale forcing, as discussed by Falkovich and Lebedev, is also examined.

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MS109

Ultimate State of Two-Dimensional Rayleigh-Bénard Convection Between Free-Slip Fixed-Temperature Boundaries

Rigorous upper limits on the vertical heat transport in two dimensional Rayleigh-Bénard convection between stress-free isothermal boundaries are derived from the Boussinesq approximation of the Navier-Stokes equations. The Nusselt number Nu is bounded in terms of the Rayleigh number Ra according to $\mathrm{Nu} \leq 0.2891\,\mathrm{Ra}^{5/12}$ uniformly in the Prandtl number Pr. This Nusselt number scaling challenges some theoretical arguments regarding the asymptotic high Rayleigh number heat transport by turbulent convection.

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MS109

An Efficient 2nd Order Scheme for Long Time Statistical Properties of the 2D NSE

We present and analyze an efficient 2nd order in time numerical scheme for the two dimensional Navier-Stokes equations in a periodic box. We demonstrate that the long time statistical properties of the scheme converge to those of the 2D NSE at vanishing time-step. Fully discrete schemes with both Galerkin FOurier and collocation Fourier will also be discussed.

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MS110

Stability and Asymptotic Structure of Steady Navier-Stokes Flows in Exterior and Aperture Domains

Viscous flows around a translating/rotating rigid body and those through an aperture are discussed. Our interest is focused on the leading profile as well as decay at infinity of the steady flow, which is related to its stability. The results depend on the motion of the body and on the compactness of the boundary. The talk will be expository and be an introduction to the following three lectures in this session.

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MS110

Stability Theorem for the Stationary Solution to Navier-Stokes Equations in Half-space

We consider stability theorem for the stationary solution to Navier-Stokes equations in half-space. More precisely, we consider the stationary solution which has the property: $(1 + x_n)u_s \in L^\infty$ and we prove its stability theorem. We will report its stability theorem.

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MS110

Asymptotic Structure of Steady Navier-Stokes Flows Past and Around a Rotating Body

We consider a rigid body moving with a constant velocity and rotating with a non-zero constant angular velocity in a three-dimensional Navier-Stokes liquid. We analyze the asymptotic structure of a weak solution to the corresponding stationary equations of motion written in a frame attached to the body. In particular, we identify the leading term in the asymptotic expansion of the solution.

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MS110

Navier-Stokes Flows Around a Rigid Body: Steady States with Finite Kinetic Energy and Long-time Behavior of Transient States

We consider an incompressible, three-dimensional Navier-Stokes flow, around a moving rigid body. The equations of motion are written with respect to a reference frame attached to the body, where the domain becomes time-independent, but such a change of frame produces new terms in the equations, related with the rotation, which difficult the analysis in exterior domains. We begin by presenting a result on existence and uniqueness of steady solutions with finite kinetic energy to this problem. The square integrability of the velocity field is shown without resorting to methods based on the (complicated) fundamental solution of the underlying linear operator. Then, we show the global existence of a transient solution which converges, when time goes to infinity, to the steady solution with finite kinetic energy.

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