IP1
Free Boundary Regularity

We discuss level surfaces of solutions u to singular semilinear elliptic equations such as $\Delta u = \delta(u)$. The level surface $u = 0$ can be interpreted as a solution to a free boundary problem, the problem of finding the optimal shape of insulating material. A variant of this equation, the Prandtl-Batchelor equation, describes the wake created by a boat. We will prove that stable free boundaries are smooth in three-dimensional space. Numerical methods are needed to explore counterexamples in higher dimensions and to establish a more robust regularity theory with numerically effective bounds.

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IP2
Fluid Biomembranes: Modeling and Computation

We study two models for biomembranes. The first one is purely geometric since the equilibrium shapes are the minimizers of the Willmore energy under area and volume constraints. We present a novel method based on ideas from shape differential calculus. The second model incorporates the effect of the inside (bulk) viscous incompressible fluid and leads to more physical dynamics. We use a parametric approach, which gives rise to fourth order highly nonlinear PDEs on surfaces and involves large domain deformations. We discretize these PDEs in space with an adaptive finite element method (AFEM), with either piecewise linear or quadratic polynomials, and a semi-implicit time stepping scheme. We employ the Taylor-Hood element for the Navier-Stokes equations together with iso-parametric elements, the latter being crucial for the correct approximation of curvature. We discuss several computational tools such as space-time adaptivity and mesh smoothing. We also discuss a method to execute refinement, coarsening, and smoothing of meshes on manifolds with incomplete information about their geometry and yet preserve position and curvature accuracy. This is a new paradigm in adaptivity.

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IP3
Rearrangement, Convection and Competition

Rearrangement theory is about reorganizing a given function (or map) in some specific order (monotonicity, cycle monotonicity etc...). This is somewhat similar to the convection phenomenon in fluid mechanics, where fluid parcels are continuously reorganized in a stabler way (heavy fluid at bottom and light fluid at top). This can also be related to some competition models in economy, where agents act according to their rank. In our talk, we make these analogies more precise by analysing the Navier-Stokes equations with Boussinesq approximation of the buoyancy force and two distinct approximations of this model (Darcy and Boussinesq). We will see how these approximations are related to the concept, well known in optimal transport theory, of rearrangement of maps as gradient of convex functions.

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IP4
The Importance of PDEs for Modeling and Simulation on Peta and Exascale Systems

As scientists and engineers tackle more complex problems involving multiphysics and multiscales and then seek to solve these problems through computation, the partial differential equation formulations which incorporate and more closely approximate the complex physical or biological phenomena being modeled will also be important to unlocking the approach taken on Peta and Exascale systems. Scientists and engineers working on problems in such areas as aerospace, biology, climate modeling, energy and other areas demand ever increasing compute power for their problems. For Petascale and Exascale systems to be useful massive parallelism at the chip level is not sufficient. I will describe some of the challenges that will need to be considered in designing Petascale and eventually Exascale systems. Through the combination of High Performance Computing (HPC) hardware coupled with novel mathematical and algorithmic approaches emerging from the original PDE formulations some efforts toward breakthroughs in science and engineering are described. While progress is being made, there remain many challenges for the mathematical and computational science community to apply ultra-scale, multi-core systems to Big science problems with impact on society. In conclusion, some discussion not only on the most obvious way to use ultra-scale, multi-core HPC systems will be given but also some thoughts on incorporating more physics in the algorithms derived from the PDE models which might allow us to better use such systems to tackle previously intractable problems.

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IP5
Singular Limits in Thermodynamics of Viscous Fluids

We discuss some recent results concerning singular limits of the full Navier-Stokes-Fourier system, where one or several characteristic numbers become small or tend to infinity. The main ingredients of our approach read as follows:

- a general *existence theory* of global-in-time weak solutions for any finite energy data;
- uniform bounds independent of the value of the singular parameters based on total dissipation balance (Second law of thermodynamics);
- analysis of propagation of acoustic waves, in particular on unbounded or "large' spatial domains.

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IP6

Q-curvature in Conformal Geometry

In this talk , I will survey some analytic results concerned with the top order Q-curvature equation in conformal geometry. Q-curvature is the natural generalization of the Gauss curvature to even dimensional manifolds. Its close relation to the Pfaffian, the integrand in the Gauss-Bonnet formula, provides a direct relation between curvature and topology. The notion of Q-curvature arises naturally in conformal geometry in the context of conformally covariant operators. In 1983, Paneitz gave the first construction of the fourth order conformally covariant Paneitz operator in the context of Lorentzian geometry in dimension four. The ambient metric construction, introduced by Fefferman and Graham , provides a systematic construction in general of conformally covariant operators. Each such operator gives rise to a semi-linear elliptic equation analogous to the Yamabe equations which we shall call the Q-curvature equation. These equations share a number of common features. Among these we mention the following: (i) the lack of compactness: the nonlinearity always occur at the critical exponent, for which the Sobolev imbedding is not compact; (ii) the lack of maximum principle: for example, it is not known whether the solution of the fourth order Q-curvature equation on manifolds of dimensions greater than four may touch zero. In spite of these difficulty, there has been significant progress on questions of existence, regularity and classification of entire solutions for these equations in the recent literature. In the talk, I will give a brief survey of the subject with emphasize on applications to problems in conformal geometry and the connection between the a class of conformal covariant operators to that of the fractional Laplacian opeators.

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IP8

Title Not Available at Time of Publication

Abstract not available at time of publication.

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IP9

Title Not Available at Time of Publication

Abstract not available at time of publication.

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CP1

Solving Nonlinear Systems of Pdes Via Real Set-Valued Maps

The existence and regularity of solutions of nonlinear PDEs resulting from constitutive relations of fluids are problems with acknowledged difficulty. We prove that the solutions of very large classes of systems of nonlinear PDE can be assimilated with real set-valued maps. Our approach is similar to the order completion method of Oberguggenberger and Rosinger but it is actually based on topological processes known as convergence structures.

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CP1

Existence of a Unique Solution to Equations Modeling Fluid Flow with Time-Dependent Density Data

We consider a system of nonlinear equations modeling the flow of a barotropic, compressible fluid. The equations consist of a hyperbolic equation for the velocity, an algebraic equation (the equation of state) for the pressure, and a modified version of the conservation of mass equation. We prove the existence of a unique solution to the model's equations with time-dependent density data and spatially-dependent velocity data, under periodic boundary conditions.

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CP1

Localization of Analytic Regularity Criteria on the Vorticity and Balance Between the Vorticity Magnitude and Coherence of the Vorticity Direction in the 3D NSE

DaVaiga has shown that $\|Du\|_q^{\frac{2q}{2q-3}} \in L^1(0,T)$ is a regularity class for the Navier-Stokes Equations for any $3 \leq q < \infty$. Beale-Kato-Majda proved the regularity for vorticity in time-space L^1L^∞-norm. Geometric conditions on the vorticity direction improve the regularity and the localized versions have been recently obtained by Grujic. The scaling-invariant regularity class of weighted L^pL^q-type for vorticity magnitude with coherence factor as a weight will be demonstrated in a localized setting.

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CP1

Fully-Coupled Aeroelastic Computations of High Reynolds Number Flows

Strong (two-way) coupling of fluid and structure presents interest to vary engineering applications, particularly when the flow is turbulent and sensitive to structural motions. A CFD based algorithm, using large-eddy simulation (LES), is proposed for the numerical investigation of strong aeroelastic coupling. The aeroelastic response of a cranked double delta wing to forced flap motion is subject of investigation. The results show that the flapping frequency influences the wing deformation, as well the flow field in the

wake of the wing.

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CP1

Mixed Bottom-Friction-Kelvin-Helmholtz Destabilization of Source-Driven Abyssal Overflows in the Ocean

Source-driven ocean currents that flow over topographic sills are important initiation sites for the abyssal component of the thermohaline circulation. These overflows exhibit vigorous space and time variability over many scales as they progress from a predominately gravity-driven down slope flow to a geostrophic along slope current. Observations show that in the immediate vicinity of a sill, grounded abyssal ocean overflows can possess current speeds greater than the local long internal gravity wave speed with bottom friction and down slope gravitational acceleration dominating the flow evolution. It is shown that these dynamics lead to the mixed frictionally-induced and Kelvin-Helmholtz instability of grounded abyssal overflows. Within the overflow, the linearized instabilities correspond to bottom-intensified baroclinic roll waves and in the overlying water column amplifying internal gravity waves are generated. The stability characteristics are described as a function of the bottom drag coefficient and slope, Froude, bulk Richardson and Reynolds numbers associated with the overflow and the fractional thickness of the abyssal current compared to the mean depth of the overlying water column. The marginal stability boundary and the boundary separating the parameter regimes where the most unstable mode has a finite or infinite wavenumber are determined. When it exists, the high wavenumber cut-off is obtained. Conditions for the possible development of an ultra-violet catastrophe are determined. In the infinite Reynolds number limit, an exact solution is obtained which fully includes the effects of mean depth variations in the overlying water column associated with a sloping bottom. For parameter values characteristic of the Denmark Strait overflow, the most unstable mode has wavelength of about 19 km, a geostationary period of about 14 hours, an e-folding amplification time of about 2 hours and a down slope phase speed of about 74 cm/s.

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CP1

On Conserved Quantities of Some Fluid Mechanical Equations

The study of conserved quantities for PDEs related to fluid mechanics is significant from both theoretical and practical points of views. For example, conservation of energy of the Euler equations is closely related to turbulence and thus plays an important role in its weak solution theory. In this talk I will present recent results giving necessary and sufficient conditions for the conservation of various quantities of the Euler, MHD and SQG equations.

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CP2

Analysis of An Epidemic Model with Age Dependency: The Case of 2009 H1N1 Influenza Outbreak

It is well known that epidemic models concerned with the infection-age are represented by PDE. In resent years, a few researchers have investigated models take account of not only infection-age but chronological age, and this assumption seems to appropriate for the case of 2009 H1N1 influenza outbreak which more likely to affect young people. Our purpose of this presentation is to develop an age-structured model of this epidemic and to study the mathematical character.

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CP2

Mathematical Analysis of a Free Boundary Combustion Model

This study concerns mathematical analysis of a free-boundary model of solid combustion. Nonlinear transition behaviors of small disturbances of front propagation and temperature as they evolve in time, as well as the large-time quasi-steady oscillations of these disturbances, are studied. Previous asymptotic solutions with some dominant modes have significant errors for almost all cases. In this study, a special asymptotic expansion method is used to improve the accuracy of the approximation.

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CP2

Stability and Bifurcation Analysis to Dissipative Cavity Soliton of Lugiato-Lefever Equation in One Dimensional Bounded Interval

We show a mathematically rigorous analysis for bifurcation structure of a spatially uniform equilibrium in nonlinear Schrödinger equations with dissipation, driving and detuning terms. Numerically, it has been reported that the “ snake bifurcation occurs. We ensure that the pitchfork bifurcation happens by using the bifurcation theory with the symmetry, and make a much finer analysis at the codimension two bifurcation point to prove the existence of fold bifurcation of nontrivial equilibrium around there.

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CP2

Mathematical Analysis to Coupled Oscillators System with a Conservation Law

We consider the 3-component reaction-diffusion system of a coupled oscillator with conservation law on an interval O = [0, 1] with homogeneous Neumann boundary condition. We can prove mathematically rigorously that the wave instability can occur under natural and appropriate conditions for this system. We especially notice that this system has a preferable cluster size of synchronization of oscillations, which tends to smaller and smaller as e goes to 0. It may be interesting that, if the effect by which the synchronized oscillation occurs is too much, then the synchronized cluster is vanishing and a kind of homogenization happens.

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CP2

Bifurcation in Two-Dimensional Electrohydrodynamics

Experimental work in annular electroconvection in a smectic film reveals the birth of convection-like vortices in the plane as the electric field intensity is increased. Modeling this phenomenon involves two-dimensional Navier-Stokes equations coupled with simplified Maxwell equations. The system satisfies the prerequisites for application of O(2)-equivariant bifurcation theory. A center manifold reduction with coefficients computed numerically unveils interesting dynamics, including stationary and spatio-temporal patterns. Results are compared with those from previous work in two-dimensional thermoconvection.

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CP2

Traveling Wave Solutions for a Class of Reaction-Diffusion Equations

Combining upper and lower solutions, monotone iterations and fixed point theorems, we study the existence and asymptotic behavior of traveling wave solutions for non-monotone reaction-diffusion equations with nonlocal delay. The upper and lower solutions are verified through integral equations and only required to be continuous. Applications of the reaction-diffusion equations include several important models in biological invasion and disease spread.

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CP3

A New Glimm Functional and Convergence Rate of Glimm Scheme for General Systems of Hyperbolic Conservation Laws

In this work, we introduce a new Glimm functional for general systems of hyperbolic conservation laws. This new functional is consistent with the classical Glimm functional for the case when each characteristic field is either genuinely nonlinear or linearly degenerate, so that it can be viewed as "optimal' in some sense. With this new functional, the consistency of the Glimm scheme is proved clearly for general systems. Moreover, the convergence rate of the Glimm scheme is shown to be the same as the one obtained for systems with each characteristic field being genuinely nonlinear or linearly degenerate.

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CP3

Stability of a New Difference Scheme With Unbounded Operator Coefficients in Hilbert Space

The initial-value problem $\frac{d^2u(t)}{dt^2} + A(t)u(t) = f(t) \quad (0 \leq t \leq T), u(0) = \varphi, u'(0) = \psi$ for hyperbolic equations in a Hilbert space H with the self-adjoint positive definite operator $A(t)$ is considered. A new second-order accurate absolutely stable difference scheme generated by integer powers of $A(t)$ for approximately solving this problem is developed. The stability estimates for the solution of this difference scheme are established. Theoretical results are supported for solving one-dimensional hyperbolic partial differential equation with initial conditions.

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CP3

Analytical and Numerical Methods in the Problem of Extinguishing of Vibration for Petrovsky Hyperbolic Equations

The problem of damping vibration described by the Petrovsky hyperbolic equation

$$(-1)^{m-1}y_{tt} = a^2 D_{xx}^m y + g(t,x), \quad 0 < t < T,$$

with the help of the dotter damper, which is moving in

small vicinities of fixed points, is considered. For example

$$g(t,x) = u(t)\delta(x - x_0 - \int_0^t v(\tau)\,d\tau),$$

where δ – delta-function of Dirac, x_0 – fixed point, $u(t)$ and $v(t)$ are two control functions. Note, that $m = 1$ corresponds to the string or membrane vibration, and $m = 2$ those ones of beam or plate. The solution of the problem of damping vibrations requires a study on the special problem of moments, the description of the set of damper movement optimal trajectories and the solution of the minimization problem of functional arising on the trajectories.

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CP3

Singular Specific Heat and Second Order Phase Transitions

Motivated by the presence of second order phase transitions in materials such as liquid helium, we examine specific heat functions containing an integrable singularity at a critical temperature. Our system is non-strictly hyperbolic, damped and may fail to be genuinely nonlinear. We will discuss breakdown of solutions, results which vary with the specific heat assumptions. A connection between steady-state solutions and dipole solutions for the porous media equation will be presented.

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CP3

What Went Wrong?

Viscosity approximations are constructed for a class of two-dimensional Riemann problems for the two-dimensinal "p-system" also called the nonlinear wave system. Under seemingly mild additional assumptions, a subsequence converges and produces a global weak solution in the limit of vanishing viscosity. However, such weak solutions provably do not exist in the generality considered.

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CP3

Anti-Diffusive Method for Hyperbolic Heat Transfer

The hyperbolic heat transfer equation is a model used to replace the Fourier heat conduction for heat transfer of extremely short duration or at very low temperature. Unlike the Fourier heat conduction, in which heat energy is transfered by diffusion, thermal energy is transfered as wave propagation at finite speed in the hyperbolic heat transfer model. Therefore methods accurate for Fourier heat conduction may not be suitable for hyperbolic heat transfer. In this paper, we present an anti-diffusive method to solve the hyperbolic heat transfer equation. The solution is compared with the analytical one as well as the one obtained from a high-order TVD (Total Variation Diminishing) scheme. The order of accuracy of the anti-diffusive method is also investigated numerically.

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CP4

Boundary Integral Solution of the Time Fractional Diffusion Equation in $\mathcal{C}^\infty$ Domains

Recently, fractional derivatives have found new applications in engineering, physics, finance and hydrology. In physics, fractional diffusion-type equations describe anomalous diffusion on heterogeneous media.
Our interest is to study the boundary integral solution of the fractional diffusion equation

$$\partial_t^\alpha \Phi - \Delta_x \Phi = 0, \quad \text{in } Q_T = \Omega \times (0,T) \qquad (1)$$

with the Dirichlet boundary condition $\Phi = g$ on $\Sigma_T = \Gamma \times (0,T)$ and the zero initial condition $\Phi(x,0) = 0,\ x \in \Omega$ and where ∂_t^α is the fractional Caputo time derivative of order $0 < \alpha \leq 1$. Boundary integral approach allows us to prove the solvability of (1) in the scale of anisotropic Sobolev spaces.

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CP4

Cauchy Problems for Semilinear Parabolic Equations

In this paper, we consider solvability of nonlinear evolution equations in Banach spaces. In particular, we study Cauchy problems for semilinear parabolic equations on unbounded domains using fixed point methods.

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CP4

On Solvability of Initial-Boundary Value Problems for Multi-Weighted Parabolic Systems

I.G. Petrovskii 1938, T. Shirota 1955 and V. Solonnikov 1965 introduced successively more and more general definitions of parabolic systems. In spite of the fact that the entries of matrix operator have different orders with respect to the spacial variables, the t-differentiation has a constant weight 2b with some natural b. Therefore all these systems can be called single-weighted. In the present work, a more general definition of multi-weighted parabolic systems is formulated and solvability of the initial-boundary value problems for the multi-weighted systems is proved in

appropriate Sobolev-type spaces.

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CP4

Asysmptotic Behavior of the Solutions for a Coupled Nonlinear Schrodinger Equations

We study the solutions of a coupled nonlinear Schrödinger equation which has been derived in many areas of physical modeling:

$$iu_t + \Delta u - (a|u|^2 + b|v|^2)u = 0, iv_t + \Delta v - (c|u|^2 + d|v|^2)v = 0$$

where the spatial dimension n is 3. Assume that (1) $a > 0$ (2) $b = c > 0$ (3) $d > 0$ are real constants. We show that the local energy of a solution is integrable in time t and the local L^2 norm of the solution approaches zero as time t approaches the infinity.

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CP4

Periodic Solutions to a $p-$Calogero Class of Evolution Equations

We consider spatially periodic solutions to the class of evolution equations

$$u_{tx}+uu_{xx} = pu_x^2-(p+1)\int_0^1 u_x^2 dx,\ 0 < x < 1,\ -\infty < p < \infty.$$

Certain choices of the parameter p give rise to physical models which arise, for instance, in highly inertial liquid crystals and in exact solutions to the equations of a perfect incompressible fluid. These have quite distinct mathematical properties. We will examine broader implications, in relation to p, for the evolution of solutions.

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CP4

Existence and Uniqueness of the Solution for the Initial-Boundary Value Problem on a Bounded Domain with Time-Dependent Boundary Conditions.

Initial-boundary value problems arising in physical applications are often defined on a bounded domain and lead to situations involving time-dependent boundary conditions. For example, in a pulse combustor reactants are added and products are removed periodically. To better understand the behavior of such system we consider a sample IBVP on a bounded domain with time-dependent boundary conditions which modifies a simple one-dimensional Cauchy problem that has been treated in the literature.

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CP5

Calculation of Self-Polarization Energies of Spherical Quantum Dots with Finite Confinement Barriers

By employing a novel model for the dielectric interface between a spherical quantum dot and the surrounding matrix, an analytical solution of the self-polarization energy of a spherical quantum dot with a finite confinement barrier is first presented. A numerical procedure is then proposed to calculate the self-polarization energy of a spherical quantum dot with arbitrary continuous model for the dielectric interface, which can fully recover the exact solution of the self-polarization energy.

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CP5

A Study of the Level Sets with Point Correspondence Approach to the Stress-Strain Analysis of Deformable Thin Elastic Membranes

One of the most challenging problems in the stress-strain analysis of deformable membranes is building accurate numerical discretizations for the membranes' complex geometries. We propose to use the level set method with point correspondence to generate a simplified geometry of a linear elastic thin membrane, perform the stress-strain analysis on this new configuration which is easier to handle numerically, and use the point correspondence mapping to predict the stress-strain distributions in the original geometry.

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CP5

Exact Solution Approach in Analysis of Dissipative Nonlinear Equation

Analytic solutions obtained for the nonlinear equation with dissipation are expressed in terms of Jacobi elliptic functions. A significant number of qualitative effects has been observed also in numerical calculations, that is scattering on inhomogeneity i.e. production of continuous-waves interference. One of the most interesting results of our investigation is discovery of the formation of the coherent state in the interaction of two exact solutions for the given model with dissipation.

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CP5

Diffusion and Homogenization Approximation for

Semiconductor Gaz Sensor Boltzmann Equation.

The aim of this work is to derive, from a kinetic description, a drift-diffusion model for electron transport in semiconductor gaz sensor, by using diffusion and homogenization approximation. A homogenized absorption term appears in the fluid model. In the presence of a self-consistent spatially oscillating electrostatic potential, the right hand side of the Boltzmann equation presents, an absorption term added to the electron-phonon operator collision. This absorption term has the periodicity of the oscillating electrostatic potential.

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CP5

Effect of Anisotropic Surface Energy in An Epitaxial Growth Model

Mullins' general diffusion equation can be used for modeling the epitaxial growth of quantum dots. Several effects have to be considered when defining a chemical potential. Stresses appear due to misfit in the crystal's grid spacings, a thin layer between the dots is apparent because of intermolecular interactions, and the inherent anisotropy of crystals results in pyramidal shapes of the islands. In self-assembly systems such as Ge/Si, flat films are unstable after they excess a critical height. Nano-dots evolve and coarsen with time. Their small slopes allow to apply a thin-film reduction. We extend a recent model by letting the surface energy depend on orientation. Simulations with a pseudospectral method show that one additional nonlinear term in the final evolution equation is suitable to guarantee faceting of the structures. A linear stability analysis explains how anisotropy destabilizes flat films. The critical height is reduced while the most unstable wave number grows with increasing anisotropy parameter.

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CP5

Motion of a Viscous Fluid Around a Rigid Body

The lecture will contain the results about the problem of a motion of a viscous fluid around a rotating rigid body in cases when velocity of fluid at infinity is or not parallel with rotation of body.

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CP5

Computation of the Band-Gap Structure of the Elasticity Operator on Periodic Waveguide

In this paper we shall study the spectral problem in the linearized elasticity. It will be shown that an infinite waveguide with periodically positioned cells, the essential spectrum contains gaps. Moreover, we construct examples where the number of band-gaps can be made arbitrarily large. Finally, we present some numerical examples by using the finite element method.

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CP6

On the Numerical Solution of Differential-Algebraic Equations (daes) By Using Legendre Polynomials Approximation

The numerical solution of differentialalgebraic equations (DAEs) using the Legendre polynomials approximation is considered in this paper. By using the theories and methods of mathematical analysis and computer algebra, a algorithm of Legendre polynomials approximation method for solving differential-algebraic equation systems was established and a Maple procedures mainproc was established. Two different problems are solved using the Legendre polynomials approximation and the solutions are compared with the exact solutions. First, we calculate the power series of a given equation system and then transform it into Legendre polynomials approximation form, which gives an arbitrary order for solving the DAE numerically.

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CP6

The Discontinuous Galerkin Method for Two Dimensional Hyperbolic Problems

We investigate the superconvergence properties of the discontinuous Galerkin method applied hyperbolic problems on triangle meshes. We show that the discontinuous finite element solution is $O(h^{p+2})$ superconvergent at the Legendre points on the outflow edge for triangles having one outflow edge. For triangles having two outflow edges the finite element error is $O(h^{p+2})$ superconvergent at the end points of the inflow edge. We use these results to construct simple, efficient and asymptotically correct *a posteriori* error estimates for hyperbolic problems on unstructured meshes.

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CP6

Discrete Compactness for the p-Version of Discrete

Differential Forms

The aim of this paper is to prove the discrete compactness property for a wide class of p finite element approximations of the Maxwell eigenvalue problem in two and three space dimensions. In a very general setting, we find sufficient conditions for the p-version of the generalized discrete compactness property which is formulated in the framework of discrete differential forms of order ℓ on a polyhedral domain in $\mathbf{R^d}$ $(0 < \ell < d)$. Joint work with Costabel, Dauge, Demkowicz, Hiptmair.

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CP6

Computing Laser Ablation by a Finite-Volume Method

In this paper we consider the computation of laser ablation as presented in (Kuzyakov, Trofimov, Shirokov, Technical Physics, 2008). In laser ablation, a laser pulse strikes a solid material thereby causing fast evaporation of the target material. Efficient computation is important since the physical experiments are difficult to implement. The computation of laser ablation presents difficulties to numerical schemes. In the spatial domain, shocks are present. Finite difference schemes require an extremely large spatial domain to accurately resolve shocks. Explicit ODE solvers, such as the forward Euler method, require a time step of order $(\Delta x)^2$. The result is a high numerical cost, even for the 1-D problem. It is prohibitive when computing 2-D problems. In this paper, we apply a high-resolution finite-volume method to the problem. The method used is the central-upwind scheme developed in (Kurganov, Tadmor, Journal of Computational Physics, 2000). The scheme is able to produce the results at extensive computational savings while accurately resolving the shocks.

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CP6

Application of the Generalized Iterative Differential Quadrature Method for Solving Lid-Driven Cavity Problem

In this work, Lid-driven cavity problem was solved by using Generalized differential quadrature method and results are given by figure and tables. Good agreements are seemed compared with other works.

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CP6

Space-Time Finite Volume Differencing Method for Effective Higher Order Accurate Schemes for General Diffusion Equations

Space-time finite volume differencing is employed to develop effective higher orde implicit, explicit and time-stepping schemes for general parabolic equations. A unified implicit local discretization error is first formulated from utilizing collocation parameters to describe the volume differencing discretization of the conservative integral form of the equation about the centroid of each regular local space-time control volume. In devising local data collocations to model the low level solution fluxes about each centroid in all directions of grid points on the control volume through minimization of the local error, the weights to describe the resulting schemes are determined. Closed form descriptions of the weights and resulting local truncation error which provide accurate couplings with other local physical parameters are optimized for consistency, stability and monotonicity of the resulting schemes.Numerical results and analysis for 1D parabolic equation where the space-time volume is 2D will be described to demonstrate higher order accuracy effectiveness.

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CP6

Numerical Analysis of First-Order Hyperbolic Partial Differential Difference Equation of Mixed Type

Several biological phenomena can be modeled by time dependent partial differential difference equations of hyperbolic type. We study first and second order finite difference approximations to find the numerical solution of first-order hyperbolic partial differential difference equation of mixed type, i.e., with delay as well as advanced argument in spatial direction. The PDE which we are studying, models the distribution of neuronal firing intervals. The proposed numerical schemes are analyzed for stability and convergence.

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CP7

On Schauder's Fixed Point Theorem Applications to Nonlinear Variational Inequality with One Or Two Obstacle

We use Schauder's fixed point theorem to obtain existence of a solution of the elliptic unilateral problem. We consider a compact convex subspace S of the space $W_0^{1,p}(\Omega)$. Then a mapping J is defined such that it is a continuous map in itself. Then J will have a fixed point. The nonlinear operator is of the form $\mathcal{A}(u) + F(x, u, Du)$ in an unbounded domain Ω of R^n. The operator is defined from the space $W_0^{1,p}(\Omega)$ into the space $W^{-1,p'}(\Omega)$. F has growth of order p with respect to variable Du satisfying the sign condition.

The obstacle is a measurable function with variable in $\bar{R}$. $\mathcal{A}$ and F satisfy Carathéodory conditions. Similar solutions can be obtained for a Parabolic Inequality. The last section gives an idea about numerical approximation of the unilateral problem.

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CP7

Asymptotic and Numerical Solutions to Laplace Young Capillary Equation at Singularity.

The Laplace Young Equation is a nonlinear elliptic PDE models capillary surfaces (static liquid surfaces). An asymptotic sequences motivated by the geometry of domain made it possible to construct an asymptotic solution in the non-power series cusp region. Also an exact-solution of an approximated equation has allowed us to obtain an accurate asymptotic solution in the circular cusp domain. At last, a fast converging finite volume element method was developed using asymptotic solutions.

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CP7

The Dirichlet Problem for Willmore Surfaces of Revolution

Boundary value problems for the "Willmore equation' are quasilinear and, in particular, frame invarint counterparts of the fourth-order linear clamped plate equation. They do not enjoy any form of a general comparison principle. In contrast to closed Willmore surfaces, only a few results are known for boundary value problems. In the talk, a particularly symmetric situation is studied. Here, one succeeds in finding strong a-priori-estimates on suitable minimising sequences and obtains a-priori bounded classical solutions.

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CP7

Numerical Approximation of Viscosity Solutions with Shocks

We consider a class of Hamilton-Jacobi equations that admits a unique viscosity solution containing shocks, [Y. Giga, Viscosity solutions with shocks, Comm. Pure Appl. Math., vol. LV, 2002], as an extension of the classical theory by Crandall and Lions (1983) where only continuous viscosity solutions are allowed. We propose a finite difference numerical scheme to approximate the solution of the extended class of equations and analyze a set of initial-boundary value problems for Hamilton-Jacobi equations arising as the convective component of nonlinear flux limiter diffusion equations.

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CP7

Multitime Dynamic Programming

This paper introduces a new type of dynamic programming PDEs for optimal control problems with performance criteria involving multiple integrals or curvilinear integrals. The main novel feature of the multitime dynamic programming PDEs, relative to the standard Hamilton-Jacobi-Bellman PDEs, is that they are connected to the multitime maximum principle. In other words, we present an interesting and useful connection between the multitime maximum principle and the multitime dynamic programming, characterizing the optimal control by means of a multitime Hamilton-Jacobi-Bellman PDE (or system) that may be viewed as a feedback law. In the case of performance criteria involving either multiple integrals or curvilinear integrals, with quadratic integrands, the new equations lead to multitime variants of the Riccati equation. Section 1 introduces the multitime Hamilton-Jacobi PDEs from geometrical point of view splitting the discussions after the type of actions (multiple integrals or curvilinear integrals). Section 2 shows how multi-time control dynamics, based on curvilinear integral action or on multiple integral action, determines the multitime Hamilton-Jacobi-Bellman PDEs via the maximum value function or its generating vector field. Section 3 describes the connection between multitime dynamic programming and the multitime maximum principle. In the general case, the HJB PDEs do not have classical (smooth) solutions, but we can introduce multitime viscosity solutions (extending the theory of P.-L. Lions and M. Crandall) or multitime minmax solutions (extending the theory of I. Subbotin).

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CP7

Over-Determined Systems of Partial Differential Equations, Equilibrium Behavior of Two-Phase Granular Mixtures and Equations of Monge-Ampere Type

The equilibrium behavior of two-phase granular mixtures is described via an over-determined, quasi-linear system of partial differential equations. In the first part of the paper we perform a compatibility analysis and various existential and regularity results are also presented. In the second part of the paper we demonstrate the connection of our system to equations of Monge-Ampere type and discuss further implications.

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CP8

Non-Existence and Existence of Localized Solitary Waves for the Two-Dimensional Long Wave-Short Wave Interaction Equations

In this study we consider the two-dimensional long wave-short wave interaction (LSI) equations which describe the interaction between high-frequency and low-frequency waves near the long wave-short wave resonance. We establish non-existence and existence results for the localized solitary waves of the LSI equations. Both the non-existence and the existence results are based on Pohozaev-type identities. We prove the existence of solitary waves by showing that the solitary waves are the minimizers of an associated variational problem.

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CP8

Dispersion in 1-D Variational Boussinesq Model

The Variational Boussinesq Model for waves over ideal fluid conserves mass, momentum, energy, and contains decreased dimensionality compared to the full problem. It is derived from the Hamiltonian formulation via an approximation of the kinetic energy, and can provide approximate dispersion characteristics. Having in mind a signalling problem, we search for optimal dispersive properties of the 1-D linear model over flat bottom and, using the finite element and spectral numerical codes, investigate its robustness.

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CP8

Scattering Resonances and the Dynamics of Deforming Bubbles in a Compressible Fluid

We consider the dynamics of a nearly spherical gas bubble in an inviscid, compressible fluid with surface tension. The time-decay of symmetric (volume) and asymmetric (shape) deformation modes is governed by *scattering resonances*. These are eigenvalues of a non-self-adjoint spectral problem associated with the linearization about the spherical equilibrium. We study the locations of scattering resonance energies and prove resonance expansions for the bubble surface perturbation and fluid velocity potential. These perturbations decay exponentially with advancing time. While the lifetime of decaying radial oscillations, $T_{radial} \sim \epsilon^{-1}$ (ϵ denotes the Mach number), there are asymmetric shape modes that decay much more slowly. In particular, the slowest decaying mode has a lifetime $T_{shape} \sim \exp(\kappa/\epsilon^2)$, $\kappa > 0$, thus occurring beyond all orders in ϵ.

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CP8

Generalized Analytic Functions in Axially Symmetric Oseen Flows

A class of generalized analytic functions arising from the Oseen equations in the axially symmetric case has been identified. For this class of functions, the generalized Cauchy integral formula has been obtained, and a series representation for the region exterior to a sphere has been constructed. The velocity field has been represented in terms of two generalized analytic functions, and it has been shown that for an exterior Oseen flow problem, those functions are uniquely determined provided that they both vanish at infinity. Also the pressure and vorticity have been determined as real and imaginary parts of the two functions representing the velocity field, and the drag exerted on a solid body of revolution in the axially symmetric Oseen flow has been expressed in terms of one of the involved generalized analytic functions. The problem of the axially symmetric Oseen flow past a solid body of revolution has been reduced to an integral equation based on the generalized Cauchy integral formula. The developed framework of generalized analytic functions has been illustrated in solving the problem of the Oseen flow past a solid sphere and solid bispheres.

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CP9

Eigenfunctions and Eigenvalues for High Energy Resonance for Non-Standard Sturm-Liouville Operators with a Perturbation of the Coulomb Potential.

Resonances for the Hamiltonian operator result from the separated radial Schrödinger equation. Perturbations e(r) of the Coulomb potential can produce a sequence of resonances. The high-energy resonance contributing equations could be the three dimensional Schrödinger operator with Coulomb potential or a non-standard Sturm-Liouville eigenproblem with interior singularities. We re-format the radial Schrödinger operator in R, which happens to be a non-standard Sturm-Liouville operator, and by specifying boundary conditions that retain the resonance poles the eigenfunctions solutions are obtained and subsequently the eigenvalues are derived. These solutions are obtained with minimal restriction on a non-constant perturbation e(r) of the Coulomb potential.

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CP9

Improved Convergence of the Allen-Cahn Equation to Generalized Motion by Mean Curvature

It is known that, as $\varepsilon \to 0$, the Allen-Cahn equation $u_t^\varepsilon = \Delta u^\varepsilon + \varepsilon^{-2} f(u^\varepsilon)$ converges — for all times— to the generalized motion by mean curvature defined via the level-set approach and viscosity solutions. In this talk, given a rather general initial data, we include the transition lay-

ers of the solutions u^ε in sets moving by mean curvature. In some special cases, this enables to obtain an $\mathcal{O}(\varepsilon|\ln\varepsilon|)$ estimate of the thickness (measured in space-time) of the transition layers.

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CP9

Existence and Asymptotic Behavior of Solutions to Quasilinear Thermoelastic Systems Without Mechanical Dissipation

We consider a class of quasilinear thermoelastic systems. The model considered is characterized by supercritical nonlinearity and accounts for large displacements and large strains. Existence of finite energy (weak)global solutions and exponential decay rates for the energy of weak solutions will be shown. The methods of proof will involve compensated compactness along with the application of special PDO non-local multipliers that have been developed in the context of the proof.

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CP9

Analysis on a Reaction-Diffusion System with Nonlinear Rate of Growth

In this talk, we present some recently qualitative results on a nonlinear reaction-diffusion system which is used as a model for animal and insect dispersal. We find that under certain parametric conditions the system admits one parameter Lie groups of transformations, which lead to two independent first integrals.

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CP9

Pseudo-Wave Functions.

ccording to J. von Neumann a set of all having a property G elements of Hilbert space B is a closed subspace PB. Here via P is denoted an orthogonal projector on this subspace. We extended this original method to finite dimensional projectors P of general form. An evolution of quantum mechanical system is described by self-adjoint energy operator H. We study finite dimensional solutions K of equation $PH - HP = K(I - P)$ with minimal rank. Any solution $\varphi(t)$ of perturbed equation $i\hbar\varphi'(t) = (H - K)\varphi(t), t > 0$ is called a pseudo-wave function if a quadratic form $((H - K)\varphi(t), \varphi(t))$ is real for all $t > 0$. Efficient Einstein-Broglie formula $E = \hbar\nu$ connects energy and frequency spectrums of object described by wave function. For object described by pseudo-wave function a correlation between these types of spectrum may be more intricate.

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CP9

Min-Max Game Theory and Non-Standard Differential Riccati Equations under Singular Estimates for $e^{At}B$ and $e^{At}G$ in the Absence of Analyticity

We consider an abstract dynamical system, which is characterized by "singular estimates", as it arises from many concrete hyperbolic/parabolic coupled PDE models, that are subject to boundary/point control and deterministic disturbance. For such a system, we study a min-max game theory problem with quadratic cost functional over a finite horizon. The problem is fully solved in feedback form via a Riccati operator which satisfies a non-standard differential Riccati equation. Several PDE-illustrations are presented.

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CP10

Numerical Valuation of Multi-Currency Interest Rate Derivatives Using a Partial Differential Equation Approach

We consider the 3D PDE arising from a multi-currency model with foreign exchange (FX) skew. Finite differences are used to discretize the space variables. Both GMRES with pre-conditioner solved by FFT techniques and the Alternating-Direction Implicit (ADI) methods are considered. We analyze the impacts of the FX skew on long-dated exotic interest rate derivatives with cancelable and knockout features, and study the effects of the boundary conditions on the accuracy of the numerical methods.

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CP10

Explicit Solutions to the Kolmogorov Backward Equation

To obtain the mean time to failure of a device, a model involving a system of two stochastic differential equations is proposed. This leads to a partial differential equation known as Kolmogorov's backward equation. This equation is solved explicitly in important particular cases. The method of similarity solutions is used.

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CP10

On Existence of Optimal Relaxed Controls for Dissipative Stochastic PDEs in Banach Spaces

We study existence of optimal relaxed controls for semilinear stochastic PDEs in UMD type-2 Banach spaces with multiplicative noise driven by a cylindrical Wiener process. The state equation is controlled through the drift coefficient which satisfies a dissipative-type condition with respect to the state-variable. The main tools are the factorization method for stochastic convolutions in Banach spaces, and certain compactness properties of the factorization operator and the class of relaxed control policies on Suslin metrisable control sets.

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CP11

Homogenization of a Heat Transfer Problem with Robin Dynamic Boundary Condition

In this paper, we deal with the asymptotic behaviour of the heat equation with highly oscillating coefficients in a ϵ-periodic two-constituent composite with dynamic heat transfer interfacial formulation.

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CP11

Geometrically Nonlinear Models in Crystal Plasticity with Penalization of Elastic Deformations

In this talk we consider models for crystal plasticity in the framework of the modern calculus of variations. As a particular example we study the case of one slip system in two dimensions with rigid elasticity and we investigate whether these models arise as Gamma limits of models in which elastic deformations are penalized. Surprisingly, the answer depends strongly on the growth conditions satisfied by the elastic and the plastic contributions to the energy. In the natural setting of quadratic potentials the compactess of sequences with finite energy is obtained by using a version of the classical div-curl lemma.

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CP11

Correctors, Homogenization, and Field Fluctuations for the $p_\epsilon(x)$-Laplacian with Rough Exponents

In this talk, properties of local fields inside mixtures of two nonlinear power law materials are studied. This constitutive model is frequently used to describe several phenomena ranging from plasticity to optical nonlinearities in dielectric media. We develop new multiscale tools to bound the local singularity strength inside microstructured media in terms of the macroscopic applied fields.

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CP11

Some Applications of Minimizing Variational Principles for Helmholtz Equation

We use the variational principles of Milton et al. for the complex Helmholtz/acoustic equation to formulate a finite element method for solving these equations that is based entirely on minimization. Various boundary conditions are addressed. Also, we apply these finite element methods to the tomography problem and use the variational principles to derive some elementary bounds on effective properties.

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MS0

Some Non Linear Problems Involving Integral Diffusions - Part II

Problems involving integral diffusion appear in questions of continuum mechanics (in variational , or "divergence form") and in probability and optimal control, from Levi processes, in " non divergence" form. In the first case, to develop a non linear theory (similar to quasilinear equations in the calculus of variations, it is necessary to develop the equivalent of the De Giorgi,Nash, Moser theory for " bounded measurable kernels coming from non local variational integrals in energy spaces of fractional derivatives . In the second, parallel to the theory of optimal control,the theory parallels the Krylov Safanov Harnack inequality and the Evans Krylov theorem. We will present the main ideas and arguments of the corresponding non local theorems.

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MS0

Some Non Linear Problems Involving Integral Diffusions

Problems involving integral diffusion appear in questions of continuum mechanics (in variational , or "divergence form") and in probability and optimal control, from Levi processes, in " non divergence" form. In the first case, to develop a non linear theory (similar to quasilinear equations in the calculus of variations, it is necessary to develop the equivalent of the De Giorgi,Nash, Moser theory for " bounded measurable kernels coming from non local variational integrals in energy spaces of fractional derivatives . In the second, parallel to the theory of optimal control,the theory parallels the Krylov Safanov Harnack inequality and the Evans Krylov theorem. We will present the main ideas and arguments of the corresponding non local theorems.

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MS1

Wavelet Analogue of the Ginzburg-Landau Energy in Variational Models of Image Processing

We discuss a wavelet analogue of the classical Ginzburg-Landau energy (WGL). Functionals of this type retain certain diffuse interface features and converge, in the Γ-sense, to a weighted analogue of the TV functional on characteristic functions of finite-perimeter sets. However, for the same values of the diffuse interface parameter, minimizers of WGL have sharper transitions between equillibria than those of the classical Ginzburg-Landau functional, thus making the WGL energy an advantageous tool for image processing. We design a variational model for multipurpose image reconstruction, where WGL is used as the regularizing energy part and the fidelity terms are defined by specifics of each application (such as image inpainting, blind deconvolution, superresolution and more).

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MS1

Variational Properties of the Mumford Shah Functional with Singular Operators

We consider functionals of the Mumford and Shah type with singular operators. In such functionals the fidelity term of the Mumford and Shah functional is replaced by a functional which penalizes the L^2 distance between the given image and a version of the unknown function which is filtered by means of a non-invertible linear operator. Depending on the type of the involved operator the resulting variational problem may have several applications in the field of image reconstruction: for instance image deconvolution preserving discontinuities in the case of convolution operators, inpainting problems in the case of suitable local operators. We study the existence of minimizers of functionals of this type in suitable classes of discontinuous functions. The discontinuity set of such functions belongs to a class of compact sets introduced by L. Rondi to study problems of crack formation in solid structures. We will consider the cases of local operators and convolution operators.

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MS1

Convergence of Perturbed Allen Cahn Equations to Forced Mean Curvature Flow

We study perturbations of the Allen–Cahn equation and prove the convergence to forced mean curvature flow in the sharp interface limit. We allow for perturbations that are square-integrable with respect to the diffuse surface area measure. We give a suitable generalized formulation for forced mean curvature flow and apply previous results for the Allen–Cahn action functional. Finally we discuss some applications.

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MS1

Existence of Weak Mean Curvature Flow with Non-smooth Forcing Term

We prove the existence of weak solution for the surface evolution problem where the velocity of hypersurface is the sum of the mean curvature vector and a given vector field. The vector field is in a suitable Sobolev space so the evolving hypersurface satisfies good measure-theoretic properties in addition to the Brakke's evolution law.

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MS2

Homogenization of Multiple Integrals Under Differential Constraints

Two-scale techniques are developed for sequences of maps $\{u_k\}_{k\in\mathbf{N}} \subset L^p(\Omega;\mathbf{R}^M)$ satisfying a linear differential constraint $\mathcal{A}u_k = 0$. These, together with Γ-convergence arguments and using the unfolding operator, provide a homogenization result for energies of the type

$$F_\varepsilon := \int_\Omega f\left(x, \frac{x}{\varepsilon}, u(x)\right)\, dx \qquad \text{with } u \in L^p(\Omega;\mathbf{R}^M), \mathcal{A}u = 0$$

that generalizes current results in the case where $\mathcal{A} = \text{curl}$. This is joint work with Stefan Krömer.

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MS2

Models for Dynamic Fracture

We introduce mathematical models for "sharp interface" dynamic fracture that make no assumption about crack geometry, etc. Existing models for static/quasi-static fracture, and phase-field models for dynamic brittle fracture, are based on variational principles that cannot be directly transferred to the dynamic setting. We show how these principles can be reformulated, so that they can be incorporated in dynamics. Time permitting, progress on existence will also be discussed.

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MS2

The Time-dependent von Krmn Plate Equation as a Limit of 3d Nonlinear Elasticity

In this talk we will discuss the asymptotic behaviour of solutions of the hyperbolic equation of nonlinear elastodynamics in a three-dimensional thin domain. More precisely, we show that when the initial data and loadings are sufficiently small in terms of the thickness, the limit dynamics corresponds to the time-dependent von Kármán plate equation.

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MS2

Simulating 2-D crack propagation with XFEM and a hybrid mesh

We will present a technique for simulating quasistatic crack propagation in 2-D which combines the extended finite element method (XFEM) with a general algorithm for cutting triangulated domains, and introduce a simple yet general and flexible quadrature rule based on the same geometric algorithm. The combination of these methods gives several advantages. First, the cutting algorithm provides a flexible and systematic way of determining material connectivity, which is required by the XFEM enrichment functions. Also, our integration scheme is straightfoward to implement and accurate, without requiring a triangulation that incorporates the new crack edges or the addition of new degrees of freedom to the system.

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MS3

Ancient Solutions to the Ricci Flow on Surfaces

We provide a classification of ancient solutions to the Ricci flow on compact surfaces. We show that the only type II ancient solutions are King-Rosenau solutions.

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MS3

Monge-Ampere Type Equations and Geometric Optics

This talk will describe recent work on problems in geometric optics related to Monge-Ampere type equations. They mostly concern with the construction of surfaces that reflect and/or refract radiation in a prescribed manner.

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MS3

Title Not Available at Time of Publication

Abstract not available at time of publication.

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MS3

On the Levi Monge Ampre Equation

We give a survey about some notions of curvatures associated with pseudoconvexity and the Levi form the way the classical Gauss and Mean curvatures are related to the convexity and to the Hessian matrix. We shall first show that these curvature equations contain information about the geometric feature of a closed hypersurface. Then, we shall show that the curvature operators lead to a new class of second order fully nonlinear equations which are not elliptic at any point. However, they have the following redeeming feature: the missing ellipticity direction can be recovered by suitable commutation relations. We shall use this property to study the Dirichlet problem for graphs with prescribed Levi curvature.

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MS4

Critical Thresholds in Hyperbolic Relaxations

Critical threshold phenomena in one dimensional 2×2 quasi-linear hyperbolic relaxation systems are investigated. We prove global in time regularity and finite time singularity formation of solutions simultaneously by showing the critical threshold phenomena associated with the underlying relaxation systems. Our results apply to the well-known isentropic Euler system with damping. This is a joint work with Hailiang Liu.

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MS4

Global Well-Posedness for the Microscopic Fene Model with a Sharp Boundary Condition

We prove global well-posedness for the microscopic FENE model under a sharp boundary requirement. The well-posedness of the FENE model that consists of the incompressible Navier-Stokes equation and the Fokker-Planck equation has been studied intensively, mostly with the natural flux boundary condition. Recently it was illustrated in [C. Liu and H. Liu, Boundary Conditions for the Microscopic FENE Models, 2008, SIAM J. Appl. Math., 68(5):1304–1315] that any preassigned boundary value of a weighted distribution will become redundant once the non-dimensional parameter $b > 2$. In this talk, we present that for the well-posedness of the microscopic FENE model ($b > 2$) the least boundary requirement is that the distribution near boundary needs to approach zero faster than the distance function. This condition is strictly weaker than the natural flux boundary condition. Under this condition it is shown that there exists a unique weak solution in a weighted Sobolev space. The sharpness of this boundary requirement is shown by a construction of infinitely many solutions when the distribution approaches zero as fast as the distance function.

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MS4

Weak Solutions and Critical Thresholds for the One-dimensional Vlasov- Poisson Equation

We give an explicit weak solution of the one-component Vlasov-Poisson equations in a single space dimension with smooth electron sheet initial data. Moreover, we give sharp conditions on whether the moments of this weak solution will blow up or not. It depends on whether or not the initial configuration of the density and velocity crosses a critical threshold. Beyond the critical time, we first construct a multi-valued solution to the Euler-Poisson equation, then we give a weak solution to the Vlasov-Poisson equation.

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MS4

Existence of Semilinear Relaxation Shocks

We establish existence with sharp rates of decay and distance from the Chapman–Enskog approximation of small-amplitude shock profiles of a class of semilinear relaxation systems including discrete velocity models obtained from Boltzmann and other kinetic equations. Our method of analysis is based on the macro–micro decomposition introduced by Liu and Yu for the study of Boltzmann profiles, but applied to the stationary rather than the time- evolutionary equations. This yields a simple proof by contraction mapping in weighted H^s spaces.

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MS5

Kinetic Theory of Synchronization

A kinetic theory for phase synchronization through binary interactions will be discussed. This theory describes the nonequilibrium phase transition from a nematic, ordered phase to an isotropic, disordered phase that occurs in a system of interacting rods, that are also subjected to random forcing. The steady-state solution for the nonlinear and nonlocal theory is obtained by expressing the Fourier transform of the orientation distribution as a function of the order parameter, which in turn, is obtained in terms of the driving strength. This exact solution is obtained using iterated partitions of the integer numbers. This kinetic theory described alignment of vibrated granular rods or chains, as well as biological systems such as molecular motors and microtubules.

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MS5

Kinetic Models for Swarming

I will present a kinetic theory for swarming systems of interacting, self-propelled discrete particles. Starting from the the particle model, one can construct solutions to a kinetic equation for the single particle probability distribution function using distances between measures. Moreover, I will introduce related macroscopic hydrodynamic equations. General solutions include flocks of constant density and fixed velocity and other non-trivial morphologies such as compactly supported rotating mills. The kinetic theory approach leads us to the identification of macroscopic structures otherwise not recognized as solutions of the hydrodynamic equations, such as double mills of two superimposed flows. I will also present and analyse the asymptotic behavior of solutions of the continuous kinetic version of flocking by Cucker and Smale, which describes the collective behavior of an ensemble of organisms, animals or devices. This kinetic version introduced in Ha and Tadmor is obtained from a particle model. The large-time behavior of the distribution in phase space is subsequently studied by means of particle approximations and a stability property in distances between measures. A continuous analogue of the theorems of Cucker-Smale will be shown to hold for the solutions on the kinetic model. More precisely, the solutions concentrate exponentially fast their velocity to their mean while in space they will converge towards a translational flocking solution.

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MS5
Self-similarity for Ballistic Aggregation Equation

We consider ballistic aggregation equation for gases in which each particle is identified either by its mass and impulsion or by its sole impulsion. For the constant aggregation rate we prove existence of self-similar solutions as well as convergence to the self-similarity for generic solutions. For some classes of mass and/or impulsion dependent rates we are also able to estimate the large time decay of some moments of generic solutions.

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MS5
Kinetic Formulations and Regularizing Effects in Degenerate Quasi-linear PDEs

We quantify the regularizing effects in a general family of quasi-linear scalar PDEs, using velocity averaging of their underlying kinetic formulations. The PDEs are first and second order equations which involve nonlinear transport and (possibly degenerate) diffusion. In particular, we use the Chen-Perthame characterization of solutions to degenerate problems to derive new regularity results for convection-diffusion and elliptic equations driven by degenerate, non-isotropic diffusion.

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MS6
A Constrained Capacitive System Arising in MEMS

A model describing and electrostatic deflections of an elastic membrane with a volume constraint, arising in MEMS, is considered. Existence and nonexistence of a solution is explored as well as the structure of the solution set for the governing equation. Time-of-fight analysis, construction of limiting singular solutions, and bifurcation diagrams, based on the variational formulation of the model, are used to determine the structure of the solution set and stability of solutions found.

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MS6
Ignition in Porous Media as a Blowup Problem

We consider a system of two reaction diffusion equations which describes initiation of combustion process in inert porous media. In the framework of the considered model initiation is associated with blow up whereas global existence of solution suggests quenching. I will present necessary conditions for global existence of solution and conditions ensuring blow up.

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MS6
Uniqueness of Steady States for a Chemotaxis Model

We consider in a disc of R^2 a class of parameter-dependent, nonlocal elliptic boundary value problems that describe the steady states of some chemotaxis systems. If the appearing parameter is less than an explicit critical value, we establish several uniqueness results for solutions that are invariant under a group of rotations. Furthermore, we discuss the associated consequences for the time asymptotic behavior of the solutions to the corresponding time dependent chemotaxis systems. Our results also provide optimal constants in some Moser-Trudinger type inequalities.

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MS6
Boundary Blowup-type Solutions to Elliptic Equations with Hardy Potentials

Semilinear elliptic equations which give rise to solutions blowing up at the boundary are perturbed by a Hardy potential involving distance to the boundary. The size of this potential affects the existence of a certain type of solutions (large solutions): if the potential is too small, then no large solution exists. The presence of the Hardy potential requires a new definition of large solutions, following the pattern of the associated linear problem. Nonexistence and existence results for different types of solutions will be given. Considerations are based on a Phragmen-Lindeloef type theorem which enables to classify the solutions and sub-solutions according to their behaviour near the boundary.

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MS7
Liouville Type Theorems in the Fluid Mechanics

In this talk we discuss Liouville type theorems in the fluid mechanics. For incompressible fluids suitable decay condition near infinity combined with sign conditions for the pressure integrals leads to triviality of the solution. For stationary compressible fluids we can omit the conditions on the pressure to lead to similar conclusion. For time dependent viscous compressiblle fluids we need to assume energy inequality for weak solution to get trivilaity of solution.

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MS7

Blow-up Problems in Fluid Mechanics: a Case Study

We study a family of 2D fluid equations, including 2D Euler and surface quasi-geostrophic (SQG) equations. In hypo-viscous dissipative cases, an oscillatory damping in long-time evolution is observed, both below/above the criticality. This suggests all-time regularity even for supercritical cases, but with a complicated transient. For inviscid cases, the growth rates of scalar gradient in L^p are compared within the family; in particular 2D Euler grows faster than SQG. This order is reversed in L^∞.

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MS7

Questions on Polymeric Equations

I will consider questions related to existence and decay of solutions to kinetic models of incompressible polymeric flow, in the case when the space of elongations is bounded, and the spatial domain of the polymer is either a bounded domain $\Omega \subset, \;\; n = 2, 3$ or it is the whole space $\mathbf{R}^3$. Consideration will also be given to solutions where the probability density function is radial in the admissible elongation vectors.

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MS7

Loss of Smoothness and Energy Conserving Rough Weak Solutions for the $3d$ Euler Equations

A basic example of shear flow was introduced by DiPerna and Majda to study the weak limit of oscillatory solutions of the Euler equations of incompressible ideal fluids. In particular, they proved by means of this example that weak limit of solutions of Euler equations may, in some cases, fail to be a solution of Euler equations. We use this example to provide non-generic, yet nontrivial, examples concerning the loss of smoothness of solutions of the three-dimensional Euler equations, for initial data that do not belong to $C^{1,\alpha}$. In addition, we use this shear flow to provide explicit examples of non-regular solutions of the three-dimensional Euler equations that conserve the energy, an issue which related to the Onsager conjecture. Moreover, we show by means of this shear flow example that, unlike to the two-dimensional case, the minimal regularity in the three-dimensional vortex sheet Kelvin-Helmholtz problem need not to be the class of real analytic solutions.

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MS8

Sharp Estimates on Minimum Traveling Wave Speed of Reaction Diffusion Systems

Abstract not available at time of publication.

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MS8

Generalized Traveling Wave Solutions and Their Propagating Speeds in Almost Periodic Media

This talk is concerned with the existence, stability, and propagating speeds of generalized traveling wave solutions in time dependent, specially, in time almost periodic and unique ergodic bistable and monostable reaction diffusion equations,

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MS8

An Introduction to Fronts in Heterogeneous Media

Abstract not available at time of publication.

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MS8

Pulsating Front Speed-up and Diffusion Enhancement in Flows

Abstract not avialable at time of publication.

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MS9

Mortar Discretization for Stokes-Darcy Systems

We consider the coupling across an interface of fluid and porous media flows with Beavers-Joseph-Saffman transmission conditions. Under an adequate choice of Lagrange multipliers on the interface we analyze inf-sup conditions and optimal a priori error estimates associated with the continuous and discrete formulations of this Stokes-Darcy system. We allow the meshes of the two regions to be non-matching across the interface. Using mortar finite element analysis and appropriate scaled norms we show that the constants that appear on the a priori error bounds do not depend on the viscosity, permeability and ratio of mesh parameters. Numerical experiments are presented.

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MS9

Mixed Finite Element Methods for a Nonlinear Stokes-Darcy Coupled Problem

In this paper we analyze mixed finite element methods for a nonlinear model of the coupling of fluid flow with porous media flow. More precisely, flows are governed by the Stokes equations in the fluid and a nonlinear Darcy equation in the porous medium, and the corresponding transmission conditions are given by mass conservation, balance of normal forces, and the Beavers-Joseph-Saffman law. The pseudostress and the velocity in the fluid, together with the velocity, the pressure, and the gradient of pressure in the porous medium, constitute the main unknowns of the model. In addition, the transmission conditions become essential, which leads to the introduction of the traces of the porous media pressure and the fluid velocity as the associated Lagrange multipliers. We show that the resulting variational formulation has a twofold saddle-point structure and then we prove the unique solvability of it. Also, we establish suitable hypotheses on the finite element subspaces ensuring that the associated Galerkin scheme becomes well posed. Finally, a reliable and efficient residual-based a posteriori error estimator is derived.

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MS9

On the Coupled Problem of Navier-Stokes, Darcy and Transport Equations

The study of a coupled flow and transport system in adjacent surface and subsurface regions is of interest for the environmental problem of contaminated aquifers through rivers. First, two models describing the coupled Navier-Stokes and Darcy equations are presented. The two models differ only by the interface condition for the balance of forces. Weak solutions are constructed using a Galerkin approach. The numerical discretization of the coupled flow problem uses continuous elements in the surface region and discontinuous finite elements in the subsurface. Numerical solutions obtained with the two models are compared as the input data (permeability, viscosity) varies. Second, a transport equation is coupled with the Navier-Stokes/Darcy flow. We prove existence and uniqueness of a weak solution. The transport equation is solved by a discontinuous Galerkin method. Error estimates for the coupled problem are obtained. Numerical simulations are shown for heterogeneous porous media.

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MS9

Domain Decomposition for Strokes-Darcy Systems

In this talk we couple deterministic and stochastic Darcy's pressure equations with log-normal permeability. We first formulate the problem as an infinity-dimensional system and then show well-posedness using inf-sup techniques. Then we formulate the finite dimensional Galerkin scheme and establish well-posedness and a priori error estimates.

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MS10

Constructing Markov Models for Barrier Options

In this talk we will present an approach for modeling barrier options which is analogous to the "local volatility" approach for modeling European options. In place of the forward equation, we employ a recent weak existence result which can handle the path dependence in the option payoff. We then use a minor variation on the martingale problem of Stroock and Varadhan to conclude that the resulting model is Markov.

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MS10

Portfolios and Risk Premia for the Long Run

This talk develops a method to derive optimal portfolios and risk-premia explicitly in a general diffusion model, for an investor with power utility in the limit of a long horizon. The market has several risky assets and is potentially incomplete. Investment opportunities are driven by, and partially correlated with, state variables following an autonomous diffusion. The framework nests models of stochastic interest rates, return predictability, stochastic volatility and correlation risk. For each relative risk aversion parameter value, the long-run portfolio, its implied risk-premia, the long-run pricing measure, and their performance on finite horizons are obtained. In the case of a single state variable, a candidate solution is derived for the finite horizon value function, and hence optimal portfolio and pricing measure. An application to a single state variable, potentially non affine, model concludes.

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MS10

Optimal Investment with Random Discrete Order Flow in Illiquid Markets

We consider an optimal investment problem where a risky asset is traded and observed only at a sequence of arrival times whose intensity approaches infinity as we get closer to maturity. We solve this stochastic control problem using dynamic programming, by first solving the integral Hamilton-Jacobi-Equation and then going trough a verification argument. The presentation is based on joint work with Paul Gassiat and Huyen Pham.

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MS10

On the Optimal Stopping Problems for Levy Processes

Value functions of optimal stopping problems for processes with Levy jumps are known to be generalized solutions of variational inequalities. Assuming the diffusion component of the process is nondegenerate, in my talk I will show that the value function is a classical solution of the variational inequality in the continuation region for problems with either finite or infinite variation jumps. Moreover, the smooth-fit property is shown via the global regularity of the value function. Our global regularity results generalize the results of Bensoussan and Lions (1984) which were developed for bounded domains. On the other hand, until now the value function was known to be $C^{2,1}$ only for the optimal stopping problems when the jumps have finite activity. This is a joint work with my Ph.D. student Hao Xing.

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MS11

A Variational Approach to Hyperspectral Image Fusion

There has been significant research on pan-sharpening multispectral imagery with a high resolution image, but there has been little work extending the procedure to high dimensional hyperspectral imagery. We present a wavelet-based variational method for fusing a high resolution image and a hyperspectral image with an arbitrary number of bands. To ensure that the fused image can be used for tasks such as classication and detection, we explicitly enforce spectral coherence in the fusion process. This procedure produces images with both high spatial and spectral quality. We demonstrate this procedure on several AVIRIS and HYDICE images. This is joint work with Michael Moeller and Todd Wittman.

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MS11

Texture - Noise Separation Model

The BV space is an excellent space to capture piecewise smooth components in an image. However, we still do not know what differentiates texture from noise in corrupted images. We will pursue a method to answer this question using homogeneous Sobolev spaces, which are good to model oscillations. The idea is that a family of the homogeneous Sobolev spaces could provide us with the distinguishable patterns when it comes to texture and noise in images.

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MS11

Exact Reconstruction of Piecewise Constant Color Images by a Total Variation Based Model

In this work we address the following colorization problem: How can a color image be recovered when the underlying gray level function is known everywhere but only small patches of color are available? We consider the Red-Green-Blue (RGB) total variation model proposed by Fornasier and subsequently studied by Fornasier and March, and we seek to study the faithfulness of the reconstructions it provides, with particular emphasis on the possible creation of new, spurious contours in the restored image. In the main result of the paper, using calibrations techniques, we show that the reconstruction is faithfull in the case of sufficiently regular piecewise constant images, if the exact information on the colors is known over a (possibly) very small but uniformly distributed area. This is joint work with I. Fonseca, G. Leoni, and F. Maggi.

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MS11

Bidirectional Inverse Consistent Deformable Image Registration

This paper presents a novel variational model for inverse consistent deformable image registration. This model deforms the source and target image simultaneously, and aligns the deformed source and deformed target images in the way that the both transformations are inverse consistent. The model does not computes the inverse transforms explicitly, alternatively it finds two more deformation fields satisfying the invertibility constraints. Moreover, to improve the robustness of the model to noises and the choice of parameters, the dissimilarity measure is derived from the likelihood estimation of the residue image. The proposed model is formulated as an energy minimization problem, which involves the regularization for four deformation fields, the dissimilarity measure of the deformed source and deformed target images, and the invertibility constraints. The experimental results on clinical data indicate the efficiency of the proposed method, and improvements in robustness, accuracy and inverse consistency.

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MS12

Quasistatic Evolution for Cam-Clay Plasticity

Cam-Clay nonassociative plasticity exhibits both hardening and softening behavior, depending on the loading. For many initial data the classical formulation of the quasistatic evolution problem has no smooth solution. We propose here a notion of generalized solution, based on a viscoplastic approximation. To study the limit of the viscoplastic evolutions we rescale time, in such a way that the plastic strain is uniformly Lipschitz with respect to the rescaled time. The limit of these rescaled solutions, as the viscosity parameter tends to zero, is characterized through an energy-dissipation balance, that can be written in a natural way using the rescaled time. It turns out that the proposed solution may be discontinuous with respect to the original time, and our formulation allows to compute the amount of viscous dissipation occurring instantaneously at each discontinuity time.

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MS12

Crack Kinking in Brittle Fracture

Smooth crack propagation in an isotropic 2d brittle material is widely viewed as the interplay between two separate criteria. Griffith's cap on the energy release rate along the crack path decides when the crack propagates, while the Principle of Local Symmetry decides in which direction that crack propagates (the kinking direction). Other competing criteria yield different and even contradictory kinking angles. We revisit crack path in the light of energetic meta-stability of the current state among suitable competing crack states. We then demonstrate that 2d crack kinking in an isotropic setting is incompatible with continuity in time of the propagation along a "smooth" path. Thus, if time continuity is viewed as essential, the classical view of crack kinking along a single crack branch seems incorrect and a change in crack direction is necessarily a more complex process.

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MS12

Symmetry of Locally Minimizing Solutions for the 3D Ginzburg-Landau System

We shall present a result classifying nonconstant entire local minimizers of the standard Ginzburg-Landau functional for maps from R^3 into R^3 satisfying a natural energy bound. Up to translations and rotations, such solutions of the Ginzburg-Landau system are given by an explicit solution equivariant under the action of the orthogonal group.

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MS12

Onsager Theory and Singularities in Nematic Liquid Crystals

We present a theory of orientational order in nematic liquid crystals which interpolates between several distinct approaches based on the director field (Oseen and Frank), order parameter tensor (Landau and de Gennes), and orientation probability density function (Onsager).

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MS13

High Field and Diffusion Asymptotics for the Boltzmann Equation

The high field asymptotics of the fermionic Boltzmann equation is sconsidered. It consists in a singular perturbation where the driving forces balance the collision effects. The limiting equation is a nonlinear conservation law for the particle density. We show the convergence to entropy solutions of the limiting conservation law. Under symmetry conditions on the collission cross section, the nonlinear limiting flux is parallel to the force field. We therefore investigate the orthogonal direction to the electric field, and prove after a suitable rescaling that the behaviour is governed by the original conservation law with an additional nonlinear diffusion in the orthogonal (to the force field) direction. The main tool used in the convergence proof is a new estimate for the dissipation of a family of kinetic entropies which converge to convex entropies of the limiting conservation law. While the entropy dissipation is usually estimated by quantities of the type $\mathrm{dist}(\mathrm{f}, \mathrm{F}_{\mathrm{eq}})$ representing the distance of the distribution function to the equilibrium set, the new estimate involves a quantity of the form $\int \mathrm{dist}(\mathrm{f}, \mathrm{F}_{\mathrm{eq}}(\mathbf{u}))\mathbf{d}\mu(\mathbf{u})$, where the macroscopic equilibria depend on a velocity variable $\mathbf{u}$ and μ is a probability measure. This estimate allows to control high velocities, pass to the limit in the diffusion current and shows the convergence to the entropy solution of the limiting equation.

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MS13

Global Existence of a Free Boundary Problem with Non-Standard Sources

We present a kinetic model with free boundary in price formation. The model consists on high nonlinear parabolic equations with nonstandard sources.Global existence results and regularity for the free boundary are given.

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MS13

Global Recovery of High Frequency Wave Fields

Computation of high frequency solutions to wave equations is important in many applications, and notoriously difficult in resolving wave oscillations. Gaussian beams are asymptotically valid high frequency solutions concentrated on a single curve through the physical domain, and superposition of Gaussian beams provides a powerful tool to generate more general high frequency solutions to PDEs. An alternative way to compute Gaussian beam components such as phase, amplitude and Hessian of the phase, is to capture them in phase space by solving Liouville type equations on uniform grids. In this work we review and extend recent constructions of asymptotic high frequency wave fields from computations in phase space. We give a new level set method of computing the Hessian and higher derivatives of the phase. Moreover, we prove that the k^{th} order phase space based Gaussian beam superposition converges to the original wave field in L^2 at the rate of $\frac{k}{2}-\frac{n}{4}$ in dimension n.

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MS13

A Bloch Band Based Level Set Method for Computing the Semiclassical Limit of Schrödinger Equations

A novel Bloch band based level set method is proposed for computing the semiclassical limit of Schrödinger equations in periodic media. For the underlying equation subject to a highly oscillatory initial data, a hybrid of the WKB approximation and homogenization leads to the Bloch eigenvalue problem and an associated Hamilton-Jacobi system for the phase in each Bloch band, with the Bloch eigenvalue be part of the Hamiltonian. We formulate a level set description to capture multi-valued solutions to the band WKB system, and then evaluate total homogenized density over a sample set of bands. A superposition of band densities is established over all bands and solution branches when away from caustic points. The numerical approach splits the solution process into several parts: i) initialize the level set function from the band decomposition of the initial data; ii) solve the Bloch eigenvalue problem to compute Bloch waves; iii) evolve the band level set equation to compute multi-valued velocity and density on each Bloch band; iv) evaluate the total position density over a sample set of bands using Bloch waves and band densities obtained in step ii) and iii), respectively. Numerical examples with different number of bands are provided to demonstrate the good quality of the method.

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MS14

Analysis of Coupled Systems Describing Sprays Dynamics

This joint work with A. Moussa, L. He and P. Zhang is concerned with a system that couples the incompressible Navier-Stokes equations to the Vlasov-Fokker-Planck equation. Such a system arises in the modeling of sprays, where a dense phase interacts with a disperse phase. The coupling arises from the Stokes drag force exerted by a phase on the other. We establish the global-in-time existence of classical solutions for data close to an equilibrium and we investigate their long time behavior. The proofs use energy estimates and the hypoelliptic structure of the system.

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MS14

Large Time Behavior of Collisionless Plasma

The motion of a collisionless plasma, a high-temperature, low-density, ionized gas, is described by the Vlasov-Maxwell equations. In the presence of large velocities, relativistic corrections are meaningful, and when magnetic effects are neglected this formally becomes the relativistic Vlasov-Poisson system. Similarly, if one takes the classical limit as the speed of light tends to infinity, one obtains the classical Vlasov-Poisson system. We study the long-time dynamics of these systems of PDE and contrast the behavior when considering the cases of classical versus relativistic velocities and the monocharged (i.e., single species of ion) versus neutral plasma situations.

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MS14

Recent Global Results for the Relativistic Boltzmann Equation

We will discuss several recent results regarding the relativistic Boltzmann equation. The talk will start with a broad overview of relativistic Kinetic theory for non-specialists. New results to be discussed include the previously open problem of stability of the Maxwellian equilibrium for the relativistic Boltzmann equation with soft interactions. The soft potentials are important for particles moving at relativistic speeds. We can also prove for the first time the global validity of the Newtonian Limit in the near Vacuum regime. Additionally we can establish the rigorous connection between the Boltzmann equation and Relativistic Euler via a Hilbert Expansion, this is joint work with Jared Speck. Furthermore, if time permits, we will discuss the relativistic Boltzmann equation coupled with it's internally generated electric and magnetic forces. Despite its importance, no global in time solutions have been established so far for this Lorentz invariant model. We prove existence of the first global in time classical solutions. This project is joint work with Yan Guo.

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MS15

Quadruple Junction Solutions in the Entire Three Dimensional Space

In this talk, I will discuss the quadruple junction solutions in the entire three dimensional space to a vector-valued Allen-Cahn equation which models multiple phase separation. The solution is the basic profile of the local structure near a quadruple junction in three dimensional crystalline material under the generalized Allen-Cahn model, and is the three dimensional counterpart of triple junction solution which is two dimensional. I will start with one dimensional heteroclinic solutions, and describe how we can construct higher dimensional solutions from the lower dimensional ones, and explain the complications and difficulties in constructing such solution in three dimensions.

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MS15

Limiting Problems for Ginzburg-Landau Models of Superconductivity in 3D

In this paper we consider the asymptotic behavior of the Ginzburg- Landau energy in 3-d, in various energy regimes. We derive applications to superconductivity and Bose-Einstein condensation: a general expression for the first critical field, and the curvature equation for the vortex lines.

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MS15

Global Solutions of Phase Transitions Equations

We study some geometric properties of global solutions of Allen-Cahn-type equations. For homogeneous equations, we deal with rigidity and symmetry properties. For mesoscopic equations, we constuct solutions with interface close to a plane or to a sphere and we discuss their multibump features.

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MS15

Singular Limit of a Reaction-diffusion System Describing Combustion in Porous Media

Abstract not available at time of publication.

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MS16

A Couple of Regularity Problems for the Mhd Equations

First, we present our work on the global regularity of classical solutions of the 2D MHD equations with mixed dissipation and diffusivity. Then, we present two regularity criteria for the 3D incompressible HMD equations. One is in terms of the derivative of the velocity field in one-direction and the other requires suitable boundedness of the derivative of the pressure in one-direction.

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MS16

Motion of Viscous Fluid Around a Rotating Rigid Body

Abstract not available at time of publication.

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MS16

The Quintic NLS as the Mean Field Limit of a Boson Gas with Three-body Interactions

In this talk we will discuss the dynamics of a boson gas with three-body interactions in dimensions d=1,2. We prove that in the limit as the particle number N tends to infinity, the BBGKY hierarchy of k-particle marginals converges to a limiting Gross-Pitaevskii (GP) hierarchy for which we prove existence and uniqueness of solutions. For factorized initial data, the solutions of the GP hierarchy are shown to be determined by solutions of a quintic nonlinear Schrödinger equation. Time permitting, we will briefly describe our new approach for studying well-posedness of the Cauchy problem for focusing and defocusing GP hierarchy.

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MS16

Inverse Problems for Some Transport Equations

Transport equations are used often to model various types of biophysical phenomena, including the propagation of light in tissues. In one limiting case one has the traditional X-ray tomography, which has been the subject of tremendous attention both for its applications and for its theoretical interest. The inverse problem, in the X-ray tomography case, is a linear one. Yet it is ill-posed and presents many computational challenges. In this talk discuss nonlinear inverse problems related to transport equations within the frame-work of the so called diffuse tomography models. The work presented here originated in joint research with F.A. Grunbaum (UCB-Mathematics) and J.R. Singer (UCB-EECS). Despite many recent progresses the inverse problem associated to diffuse tomography still presents a number interesting open problems.

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MS17

Interface Evolution: Water Waves in 2-D

We study the free boundary evolution between two irrotational, incompressible and inviscid fluids in 2-D without surface tension. We prove local-existence in Sobolev spaces when, initially, the difference of the gradients of the pressure in the normal direction has the proper sign, an assumption which is also known as the Rayleigh-Taylor condition. The well-posedness of the full water wave problem was first obtained by Wu. The methods introduced in this paper allows us to consider multiple cases: with or without gravity, but also a closed boundary or a periodic boundary with the fluids placed above and below it. It is assumed that the initial interface does not touch itself, being a part of the evolution problem to check that such property prevails for a short time, as well as it does the Rayleigh-Taylor condition, depending conveniently upon the initial data. The addition of the pressure equality to the contour dynamic equations is obtained as a mathematical consequence, and not as a physical assumption, from the mere fact that we are dealing with weak solutions of Euler's equation in the whole space.

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MS17

Dispersive Properties of Surface Water Waves

I will speak on the dispersive character of waves on the interface between vacuum and water under the influence of surface tension and possibly gravity. I will begin by giving a precise account of the formulation of the surface water-wave problem and discussion of its defining features. I will describe the local smoothing effect and the gain of regularity for the nonlinear water-wave problem with some detail of the proofs. I will examine the frequency-localized and global dispersion of the linear system and indicate how the microlocal dispersion estimates gives the Strichartz estimates for the nonlinear problem. If time permits, I will speak on the application of global dispersion on the long-time existence. This work is partly joint with Hans Christianson and Gigliola Staffilani (MIT).

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MS17

How Gravity Can Stabilize Kelvin-Helmholtz Instabilities and Applications

The mathematical properties of the motion of the interface between two layers of fluid differ dramatically from what is observed for water-waves (which is a particular case of the two fluids problem with an upper fluid of zero density). While the water-waves equations are well-posed, with or without surface tension, on time scales that are pertinent for the observation of oceanographic phenomena, the "interfacial waves" equations are known to be ill-posed without surface tension, due to Kelvin-Helmotz instabilities. It has been shown that adding surface tension allows the solution to exist locally in time. However, the existence time vanishes as the surface tension goes to zero and since the physical value of surface tension is very small, this wellposedness result does not explain why we can observe many stable manifestions of interfacial waves. In this talk, we will show that it is possible to control the growth of Kelvin-Helmoltz instabilities by a careful analysis of the role played by gravity and by the physical characteristics (depths of the layers, amplitude, etc.) of the flow. In particular, we exhibit a new condition for the existence of "stable" solutions to the "interfacial waves" equations, that can be seen as a generalization of both the Rayleigh-Taylor criterion for the stability of surface waves and the Chandrasekhar law on the instable modes in shear flows. high-level commands. Do not include references or citations separately at the end of the abstract. Instead, all citations must be in text in the general form [Authorname, Title, etc]

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MS17
Almost Global Wellposedness of the 2-D full Water Wave Equation

We consider the problem of global in time existence and uniqueness of solutions of the 2-D infinite depth full water wave equation. It is known that this equation has a solution for a time period $[0, T/\epsilon]$ for initial data of type $\epsilon\Phi$, where T depends only on Φ. We show that for such data there exists a unique solution for a time period $[0, e^{T/\epsilon}]$. This is achieved by better understandings of the nature of the nonlinearity of the water wave equation.

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MS18
Domain Decomposition for Heterogeneous, Multiscale Problems

Multiscale methods are used to solve flow problems in porous media with heterogeneous permeability. We develop multiscale mortar mixed finite element discretizations for second order elliptic equations. The continuity of flux is imposed via a mortar finite element space on a coarse grid scale, while the equations in the coarse elements (or subdomains) are discretized on a fine grid scale. The mortar approximation space is based on homogenization, and the method is shown to converge with respect to this microstructure.

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MS18
On the Coupling of Hyperbolic and Elliptic Equations: Comparison Between Virtual Control Methods and Extended Variational Formulations

We address the coupling of an advection equation with a diffusion-advection equation, for solutions featuring boundary layers. We consider both non-overlapping and overlapping domain decompositions and we face up the heterogeneous problem by different approaches. Starting from a rigorous variational analysis, the aim of this research is to investigate if other approaches may be considered to formulate this heterogeneous problem, for a possible extension to more general couplings. In particular we will consider the virtual control approach, based on the optimal control theory, and an extend variational formulation recently proposed for geometric multiscale problems.

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MS18
Non Conforming Space-time Domain Decomposition Algorithms for Coupling Heterogeneous Problems

In this talk we present non conforming space-time domain decomposition algorithms for solving evolution problems with discontinuous coefficients. The objective is long time computations in highly discontinuous media such as nuclear waste disposal simulations, or climate modeling. The strategy is to split the time interval into time windows and to perform, in each window, few iterations of Optimized Schwarz Waveform Relaxation methods [D. Bennequin, M.J. Gander, and L. Halpern., *A homographic best approximation problem with application to optimized Schwarz waveform relaxation*, Math. of Comp., pages 259-266, 2009]. It has been proposed in [L. Halpern and C. Japhet, *Discontinuous Galerkin and Nonconforming in Time Optimized Schwarz Waveform Relaxation for Heterogeneous Problems*, In U. Langer, M. Discacciati, D.E. Keyes, O.B. Widlund, and W. Zulehner, editors, Decomposition Methods in Science and Engineering XVII, volume 60 of Lecture Notes in Computational Science and Engineering, pages 211-219. Springer, 2008] to use a discontinuous Galerkin method in time as a subdomain solver in order to have a high degree of accuracy, time-stepping approaches, and ultimately adaptive control of the time step, see [C. Johnson, K. Eriksson, and V. Thomee, *Time discretization of parabolic problems by the discontinuous Galerkin method*, RAIRO Modl. Math. Anal. Numr., 19, 1985], [Ch. Makridakis and R. Nochetto, *A posteriori error analysis for higher order dissipative methods for evolution problems*, Numerische Mathematik, 2007]. We present the analysis of the method and numerical results to illustrate the performances of the method.

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MS18
Filtration Into Deforming Porous Media

We review the theory of flow through deformable porous media. Then we describe more recent extensions to composite media, partially-saturated flow, flow through rather general poro–inelastic media, and coupling to the Stokes flow in an adjacent open channel. The problems will be posed and resolved in appropriate variational formulations.

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MS19
Convergence to Homogenized and Stochastic PDEs

Equations with small scale structures abound in applied sciences. Many such structures cannot be modeled at a microscopic level and thus require that one understand their macroscopic influence. I will consider the situation of partial differential equations with random, highly oscillatory, potential. One is then interested in the behavior of the solutions to that equation as the frequency of oscillations in the micro-structure tends to infinity. Depending on spatial dimension and the decorrelation properties of the random potential, I will show that the limit is the solution to either a deterministic, homogenized (effective medium) equation or a stochastic equation with multiplicative noise that should be understood in the sense of a Stratonovich product. More precisely, there is a critical spatial dimension above which we observe convergence to a deterministic solution and below which we observe convergence to a stochastic solution. In the former case, a theory of correctors to homogenization allows one to capture the remaining randomness in the solution to the equation with the small scale structure. Once properly rescaled, this corrector is shown to solve a stochastic equation with additive noise.

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MS19

SPDE Limits of the Random Walk Metropolis Algorithm in High Dimensions

Diffusion limits of MCMC methods in high dimensions provide a useful theoretical tool for studying efficiency. In particular they facilitate precise estimates of the number of steps required to explore the target measure, in stationarity, as a function of the dimension of the state space. However, to date such results have only been proved for target measures with a product structure, severely limiting their applicability to real applications. I will present a study diffusion limits for a class of naturally occuring high dimensional measures and their associated MCMC algorithm. The diffusion limit to an infinite dimensional Hilbert space valued SDE (or SPDE) will be proved.

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MS19

Unbiased Random Perturbations of Navier-Stokes Equation.

A random perturbation of a deterministic Navier-Stokes equation is considered in the form of an Stochastic PDE with Wick product in the nonlinear term. The equation is solved in the space of generalized stochastic processes using the Cameron-Martin version of the Wiener chaos expansion. The generalized solution is obtained as an inverse of solutions to corresponding quantized equations. An interesting feature of this type of perturbation is that it preserves the mean dynamics: the expectation of the solution of the perturbed equation solves the underlying deterministic Navier-Stokes equation. From the stand point of a statistician it means that the perturbed model is unbiased. The talk is based on a joint work with R. Mikulevicius.

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MS19

Homogenization of Hamilton-Jacobi Equations in Time-Space Random Environments

We present results on the stochastic homogenization of Hamilton-Jacobi equations in time-space random environments. Previous results of Souganidis, 1999, and simultaneously by Rezakhanlou and Tarver, 2000, had been in the context of random fluctuations in space only. Special attention will be placed on the interplay between the use of the Subadditive Ergodic Theorem and continuity estimates for solutions of these equations that depend only on the growth of the Hamiltonian.

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MS20

Generalized Newton-type Methods for Energy Formulations in Image Processing

Many problems in image processing are addressed via the minimization of a cost functional. The most prominently used optimization technique is gradient-descent, often used due to its simplicity and applicability where other techniques, e.g., those coming from discrete optimization, can not be applied. Yet, gradient-descent suffers from slow convergence, and often to just local minima which highly depend on the initialization and the condition number of the functional Hessian. Newton-type methods, on the other hand, are known to have a faster, quadratic, convergence. In its classical form, the Newton method relies on the L2-type norm to define the descent direction. In this work, we generalize and reformulate this very important optimization method by introducing Newton-type methods based on more general norms. Such norms are introduced both in the descent computation (Newton step), and in the corresponding stabilizing trust-region. This generalization opens up new possibilities in the extraction of the Newton step, including benefits such as mathematical stability and the incorporation of smoothness constraints. We first present the derivation of the modified Newton step in the calculus of variation framework needed for image processing. Then, we demonstrate the method with two common objective functionals: variational image deblurring and geometric active contours for image segmentation. We show that in addition to the fast convergence, norms adapted to the problem at hand yield different and superior results.

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MS20

From TV-L1 Model to Continuous Graph-Cuts: Global & Fast Optimization Algorithms for Image & Geometry Processing

In this talk, I will review some recent developments in global continuous optimization methods for image and geometry processing. Starting from the TV-L1 model for image denoising, we will show that this model has opened the path to a new paradigm to define convex formulations for e.g. image segmentation and geometry reconstruction. Indeed, unlike state-of-the-art methods, the proposed convex energy minimization approach allows to solve geometry problems independently of initial condition. Besides, this approach provides fast optimization algorithms, borrowed from operator splitting techniques, to solve energy minimization problems related with non-linear hyperbolic PDEs. We will show some results in segmentation and surface reconstruction. Joint work with T.F. Chan, S. Osher, T. Goldstein (UCLA).

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MS20

Coarsening in High Order, Discrete, Ill-posed Diffusion Equations

We study the discrete version of a family of ill-posed, nonlinear diffusion equations of order $2n$. The fourth order ($n = 2$) version of these equations constitutes our main motivation, as it appears prominently in image processing and computer vision literature. It was proposed by You and Kaveh as a model for denoising images while maintaining sharp object boundaries (edges). The second order equation ($n = 1$) corresponds to another famous model from image processing, namely Perona and Maliks anisotropic diffusion, and was studied previously. The equations presented in this talk are high order analogues of the Perona-Malik equation, and like the second order model, their continuum versions violate parabolicity and hence lack well-posedness theory. As in the previous work, we follow a recent technique by Kohn and Otto to establish rigorous upper bounds on the coarsening rate of the discrete versions of these high order equations, in any space dimension and for a large class of diffusivities. However, the high order nature of our equations requires different arguments and constructions from before.

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MS20

Geodesics in Level-set Based Shape Space

The equations for geodesic movement (with respect to an appropriately constructed metric) of a level-set function representing a shape variable are derived. The related equations for parallel transport are also constructed. Geodesic movement and parallel transport are used to realize algoritmic concepts for non-linear optimization in the non-linear level-set based shape space.

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MS20

A Review of the Bregman Methods

We review four Bregman methods that arise in applications of imaging, compressed sensing, and other inverse problems. We explain their numerical properties and highlight their relationships with the augmented Lagrangian and alternating direction methods. Recent results on the Bregman methods are included. Applied to ℓ_1-type regularization, the original Bregman method has an exact error cancellation property that leads to machine-precision solutions. In addition, we briefly show an exact penalty property of the linearized Bregman method. These properties explain the great performance of the Bregman methods. The analysis and discussions broadly apply to polyhedral regularization functions such the (weighted) ℓ_1-norm, total variation, piece-wise linear functions, as well as the matrix nuclear norm.

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MS21

Radial Symmetry of Positive Solutions to Nonlinear Polyharmonic Dirichlet Problems

We extend the celebrated symmetry result of Gidas-Ni-Nirenberg to semilinear polyharmonic Dirichlet problems in the unit ball. In the proof we develop a new variant of the method of moving planes relying on fine estimates for the Green function of the polyharmonic operator. We also consider minimizers for subcritical higher order Sobolev embeddings. For embeddings into weighted spaces with a radially symmetric weight function, we show that the minimizers are at least axially symmetric. This result is sharp since we exhibit examples of minimizers which do not have full radial symmetry. The lecture is based on joint work with E. Berchio (Milan) and T. Weth (Frankfurt).

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MS21

"Almost Positivity"' in the Fourth Order Clamped Plate Equation

A classical example for a fourth order problem in mechanics is the linear clamped plate equation. It is known that it does not satisfy any form of a general maximum or positivity preserving (comparison) principle. However, there are positivity issues as e.g. "almost positivity' to be discussed. In particular, it is shown that the negative part of the corresponding Green function obeys much sharper bounds than the singular positive part. For example, if $n > 4$, the negative part is bounded while the positive part displays the singular behaviour of $|x - y|^{4-n}$.

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MS21

Q-curvature Equation in Conformal and CR Geometry

In this talk, I plan to outline the role this 4th order equation plays in the conformal geometry of four dimension, as well as the CR geometry in 3-dimension. In CR geometry, there is a natural 4th order operator which plays an important rolein the analogue of the Bochner formula governing the kernel of the sub-Laplacian.

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MS21

Fourth Order Elliptic Problems Involving Singular and Critical Nonlinearities

We study a class problems for the biharmonic operator with Dirichlet boundary conditions in dimension four involving critical growth corresponding to a Trudinger-Moser embedding.

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MS22

On the Classical Solutions of Two Dimensional Inviscid Rotating Shallow Water System

We prove the global existence and asymptotic behavior of the classical solutions for two dimensional inviscid Rotating Shallow Water system with small initial data subject to the zero-relative-vorticity constraint. One of the key steps is a reformulation of the problem into a symmetric quasilinear Klein-Gordon system, whose existence of the classical solutions is then proved with combination of the vector field approach and the normal forms, adapting ideas developed in [1]. The symmetric form of the system facilitates the closure of energy estimates for the problem. We also probe the case of general initial data and reveal a lower bound for the lifespan that is almost inversely proportional to the size of initial relative vorticity. [1] Tohru Ozawa, Kimitoshi Tsutaya, and Yoshio Tsutsumi, Global existence and asymptotic behavior of solutions for the Klein-Gordon equations with quadratic nonlinearity in two space dimensions, Math. Z. 222 (1996), no. 3, 341362.

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MS22

Continuous Solutions of Hyperbolic Conservation Laws

Abstract not available at time of publication.

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MS22

New Models of Chemotaxis: Analysis and Numerics

Patlak-Keller-Segel (PKS) system is a classical PDE model of the chemotaxis. The system admits solutions that develop delta-type singularities within a finite time. Even though such blowing up solutions model a concentration phenomenon, they are not realistic since biological cells do not converge to one point (while the cell density grows sharply, it must remain bounded at all times). I will present a new chemotaxis model, which can be viewed as a regularized PKS system. The proposed regularization is based on a basic physical principle: boundedness of the chemotactic convective flux, which should depend on the gradient of the chemoattractant concentration in a nonlinear way. Solutions of the new system may develop spiky structures that model the concentration phenomenon. However, both cell density and chemotattractant concentration remain bounded as supported by both our analytical results and extensive numerical experiments.

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MS22

A Low Mach Number Limit from a Dispersive Navier-Stokes System ¿ to a Ghost-Effect System

A low Mach number limit for classical solutions of a dispersive system beyond the full Navier-Stokes equations is investigated. We prove the convergence of this dispersive system to a ghost effect system studied extensively by Sone in the whole space case. The combined effects of large temperature variations, thermal conduction as well as the dispersive structure are taken into account.

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MS23

Well-posedness and Mean-field Limit for Kinetic Models of Collective Motion

There has been a recent interest in models for the complex behavior of large groups of animals, such as flocks of birds, swarms, or schools of fish. Kinetic equations, which involve the time evolution of the distribution function of individuals depending on their position and velocity, are tentative models for these phenomena, and raise many interesting mathematical questions. In this work, we give a well-posedness theory for kinetic PDE models for the collective behavior of a group of individuals that interact through a pair potential and/or try to adapt their velocity to the average velocity of their neighbours, possibly including also self-propulsion effects. The aim is to give a solid mathematical basis for the study of these models and the range of phenomena they display.

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MS23

Accuracy and Consistency of Spectral-Lagrangian Approximating Methods for the Boltzmann Equation

We study the accuracy and consistency properties of the recent Lagrangian based spectral method to produced an approximating scheme to solutions of the Boltzmann equation [1,2]. We develop bounds on the optimization correction in terms of spectral accuracy and also prove consistency and conservation properties of the scheme. We also obtain error estimate for the conservation routine implemented as an extended isoperimetric problem with the moment conservation properties as the constraints. Combining Sobolev estimates of the collisional integral with projection error and conservation correction estimates yields a Lagrange-spectral error result.

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MS23

Fractional Diffusion Limits for Kinetic Equations

We will discuss some diffusion limits for linear Boltzmann equations when the equilibrium distribution function is not a Maxwellian distribution. In particular, we will show that for an appropriate time scale, the small mean free path limit gives rise to fractional diffusion equations.

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MS23

Phase Transitions for the McKean-Vlasov Equation in Finite Volume

We consider a nonlinear parabolic equation that describes the mean-field limit for a system of N diffusions in a bounded domain interacting through a finite-range potential V. We show that for all potentials that are not of positive type (characterized by the positivity of the Fourier transform of V) the system generically has a first-order phase transition at the critical temperature, which is manifested by the nonuniqueness/instability of the steady solutions. An interesting feature of the model is that the "trivial" steady state characterized by the uniform density remains locally stable in the subcritical region while for sufficiently large perturbations the dynamics prefers other, spatially nonuniform stady states.

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MS24

Entire Solutions of the Allen Cahn Equation in the Hyperbolic Space

Qualitative properties of entire solutions of equations with double well potential in the Hyperbolic space will be discussed, both in relation with conditions at the asymptotic boundary and with conditions of stability or minimality. Differences and similarities with respect to the euclidean case will be discussed.

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MS24

A Moving Boundary Problem Involving Surface Tension

Abstract not available at time of publication.

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MS24

Stability in the Stefan Problem with Surface Tension

Abstract not available at time of publication.

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MS24

Domain Walls and Triple Junctions

The studies of domain walls and triple junctions arise in many applications. Their appearences , such as honeycomb structures in 2D, are deceptively simple. If the underlying variational energy driven such a structure is giving by the Surface Area, it is then possible to describe some geometric and analytic properties of the structure via the classical minimal surfaces theory. In many applications, however, such a structure is driven by the so-called stress, that is, the Bulk energy, then not much were known before. In this lecture, I shall describe some recent progress on the Bulk-energy driven domain walls and multiple junctions.

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MS25

Global Bv Solutions to Heat Flows of Linear

Growth Maps into Spheres

In this talk I shall first present some recent developments for p-harmonic map heat flows into spheres, in particular, for 1-harmonic map heat flow. The highlight of the developments is the BV (bounded variation) solution theory for the flow, which will be reviewed in detail. I shall then discuss the extension of these results to heat flows for a class of linear growth maps. Finally, applications (and their numerical approximations) of these geometric flows to color image denoising based on the chromaticity and brightness decomposition will also be discussed. The results presented in this talk are based on recent joint works with John Barrett of Imperial College (UK), Andreas Prohl of University of Tuebengin (Germany), and Minun Yoon of University of Tennessee.

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MS25
Local and Nonlocal Weighted p-Laplacian Evolution Equations with Neumann Boundary Conditions

In this talk we study existence and uniqueness for solutions of the nonlocal diffusion equation with Neumann boundary conditions

$$u_t(t,x) = \int_\Omega J(x-y) g\left(\frac{x+y}{2}\right) |u(t,y)-u(t,x)|^{p-2}(u(t,y)-u(t,x))\,dy$$

in $]0,T[\times\Omega$, and for solutions of its local counterpart

$$\begin{cases} u_t = \operatorname{div}(g|\nabla u|^{p-2}\nabla u) & \text{in}]0,T[\times\Omega, \\ g|\nabla u|^{p-2}\nabla u\cdot\eta & \text{in}]0,T[\times\partial\Omega. \end{cases}$$

We consider $1 \le p < \infty$ and $g \ge 0$. We pay special attention to the case in which g vanishes somewhere in Ω even in a set of positive measure. Joint work with: F. Andreu, J. Rossi and J. Toledo

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MS25
Regularity of the Total Variation Flow

I would like to investigate phenomena appearing in analysis of a class of systems represented by the total variation flow. The basic gaol is to create a new point of view at the regularity and the notion of solution when the nonlinear diffusion is so strong that it causes nonlocal effects. Our approach will allow us to call the obtained solutions almost classical, although the classical theory sees this type of equations as meaningless. The talk will be based on joint results with Piotr Rybka.

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MS25
A Singular Weighted Mean Curvature Flow in the Plane Hamilton-Jacobi Equation with an Unusual Free Boundary

We study evolution of simple planar curves driven by the weighted mean curvature flow (wmc)

$$\beta V = \kappa_\gamma + \sigma$$

when the anisotropy function is piecewise linear and convex. The diffusion in certain direction is so strong that facets are created. At the same time in other directions the equation degenerates to a first order equation. In order to prove existence and uniqueness of solutions to the resulting problem we develop a theory of viscosity solutions to Hamilton-Jacobi equation with discontinuous Hamiltonian. In particular, we show a comparison principle and a stability theorem.

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MS26
Expanding the Prodi-Serrin Critera for Regularity to Weak-L^p Spaces

In this talk we discuss weakening the Prodi-Serrin criteria for regularity of Leray-Hopf solutions to the 3d Navier-Stokes equation. In particular, the criteria is expanded to include solutions which satisfy the following bound:

$$\int_0^t \frac{\|u(s)\|^p_{L^{q,\infty}(\mathbf{R}^3)}}{e + \log(e + \|u(s)\|_{L^\infty(\mathbf{R}^3)})}\,ds < \infty$$

Here p and q satisfy the usual relation $1 = \frac{3}{q} + \frac{2}{p}$. The result is based on bounding the local energy in terms of weak L^p norms, a scaling argument, and an application of the De Giorgi method.

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MS26
Stochastic Particle Systems for the Navier-Stokes and Burgers Equations

I will introduce an exact stochastic representation for the 3D-Navier-Stokes equations based on noisy Lagrangian paths, and use this to construct a (stochastic) particle system. On any fixed time interval, this particle system converges to the Navier-Stokes equations as the number of particles goes to infinity. Curiously, a similar system for the (viscous) Burgers equations shocks in finite time, and solutions can not be continued past these shocks using classical methods. I will describe a resetting procedure by which these shocks can (surprisingly!) be avoided.

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MS26

Exterior Problems

We develop some techniques to deal with exterior problems for equations of interest to fluid dynamics, such as the two dimensional dissipative quasi-geostrophic equation

$$\frac{\partial\theta}{\partial t} + u\cdot\nabla\theta + \kappa(-\Delta)^{\alpha}\theta = 0, \qquad 0 < \alpha < 1.$$

The emphasis is in obtaining decay of solutions of these equations extending the Fourier splitting methods used in the full space situation.

Tomas Schonbek
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MS26

Higher Derivatives Estimates for the 3D Navier-Stokes Equation

We will present, in this talk, new applications of De Giorgi's methods and blow-up techniques to fluid mechanics problems. We introduce a new nonlinear family of spaces allowing to control higher derivatives of solutions to the 3D Navier-Stokes equation. Finally, we show a regularity result for a reaction-diffusion system which has almost the same supercriticality than the 3D Navier-Stokes equation.

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MS26

Oscillations and Regularity of the Navier-Stokes Equations

We shall give some global regularity results for the 3D Navier-Stokes equations when the initial data are oscillating in some sense. The proofs rely on thin domains techniques.

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MS27

Fully Nonlinear Hamiltonian Equations for for the Dynamics of Fluid Films

We discuss the exact nonlinear equations for the dynamics of fluid films, modeled as a two dimensional manifold. Our main goal is to illustrate the differences and similarities between the fluid film equations and Euler's equations, their classical three dimensional counterpart. Since the geometry of fluid films is fundamentally different – three dimensional velocity field on a two dimensional support with a time varying Riemannian metric – all classical theorems must be properly modified. We offer adaptations of the following theorems: conservation of mass and energy, pointwise conservation of vorticity and Kelvin's circulation theorem. We present proofs of these theorems by employing the calculus of moving surfaces. It is of great interest to develop a simplified model that captures normal deformations of fluid films by assuming tangential velocities vanish while preserving the exact nonlinear nature of the full system. This cannot be accomplished simply by neglecting the tangential components, for such an attempt leads to internal contradictions. Instead, we alter the initial formulation and present a modified variational approach that leads to a simplified system of equations capable of capturing a broad range of deeply nonlinear effects.

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MS27

Stability of Periodic Water Waves

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

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MS27

Spectral Stability of Traveling Water Waves

The water wave problem arises in a number of problems of practical interest, consequently its reliable and accurate numerical simulation is of central importance in many applications. Recently, an efficient, stable, and high-order Boundary Perturbation scheme for simulating traveling water waves (due to the author and F. Reitich) has been extended to address the equally important topic of their dynamic (spectral) stability. In this talk we will discuss this algorithm and present new results on the "motion" of the spectrum of the linearized water wave equations as the traveling waveform is varied. In particular, we will focus upon the radius of convergence of a Taylor series expansion of the spectral data and its possible connection to spectral instability of traveling water waves.

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MS27
Spectral Stability of Solitary Waves on Water

The talk will discuss spectral stability of two-dimensional solitary waves on water. It is assumed that the fluid is bounded by a free surface and a rigid horizontal bottom. The solitary wave is moving under the gravity and the surface tension is ignored. It was known that the fully nonlinear Euler equations have a solitary-wave solution. In this talk, we will show that the linear operator arising from linearizing the Euler equations around the solitary-wave solution has no spectrum points lying on the right half of the complex plane, which implies the spectral stability of the solitary waves. This is a joint work with R. Pego.

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MS28
Physiological Models for Evaluating Biocompatibility of Heart Assist Devices

Several challenges and methods in blood pump design are described. The objective often involves the unique behavior of blood as the flowing medium, necessitating, e.g., accurate modeling of thrombosis and hemolysis. The fluid constitutive behavior, in particular shear-thinning, may affect the outcome of shape optimization more than it affects direct flow analysis. Finally, target applications often involve intricate time-varying geometry, and thus, realistic solutions can be only obtained on high-performance parallel computers.

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MS28
Partitioned Strategies for Strong Coupling of Dimensionally-heterogeneous Models for the Navier-Stokes Equations

In this work an iterative procedure is developed to tackle the problem of strong coupling of dimensionally-heterogeneous models in fluid mechanics. The procedure proposed here makes use of a reinterpretation of the problem as a partitioned problem yielding a system of nonlinear equations in terms of interface variables, for which classical non-linear solvers are applied. The goal is to couple different mathematical models, which can be treated as black boxes, through the imposition of proper boundary information at the coupling interfaces. The main application for which this strategy is envisaged arises when addressing the interaction between hydraulic components which aim at retrieving information from different geometrical scales in complex hydraulic systems. The specific examples are provided in the context of coupling 0D lumped equations and 2D/3D Navier-Stokes equations. The potentialities and the performance of the strategy are shown through several examples involving transient flows.

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MS28
Fluid-Structure Interaction in Blood Flow

The speaker will give an overview of the basic issues and difficulties associated with the study of fluid-structure interaction in blood flow. A list of open problems and the related results obtained by the hemodynamics group in Houston will be presented. They include an existence result for a nonlinear hyperbolic-parabolic effective moving boundary problem, a design of a novel, stable, loosely-coupled computational scheme for the full 2D/3D problem, and a novel model for the mechanical behavior of endovascular stents. Movies showing application to the medically relevant problems will be presented.

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MS28
Data Assimilation in Fluid-structure Problems. Application to blood flows.

We present a method to estimate the state and the parameters in systems involving the mechanical interaction of a viscous incompressible fluid and an elastic structure. We consider a sequential approach inspired by Kalman filtering strategies assuming observations on structural displacements. The proposed method is illustrated through examples inspired from vascular biomechanics.

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MS29
On Some Averaging Results for SPDE's

The behavior of solutions of infinite dimensional systems on time intervals of order $^{-1}$ was not very well understood, even if applied mathematicians believed that the averaging principle holds and usually approximate of the slow motion by the averaged motion, also with $n = \infty$. In my talk I will present some results on multiscaling limits for systems of SPDE's, obtained also in collaboration with M. Freidlin. I will be mainly concerned with the problem of the validity of an averaging principle for general systems of fully coupled SPDE's of reaction diffusion type and I will also study normal deviations from the averaged motion for a particular class of systems.

Sandra Cerrai
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MS29

Singular Perturbations of Stochastic PDEs

We study of a class of parabolic PDEs depending on a small parameter ϵ with the following very interesting feature. As $\epsilon \to 0$, the solutions to the PDEs converge to the solutions to the heat equation. However, when we add to these equations additive space-time white noise (of order one), their solutions converge to the solutions to a stochastic PDE that is *different* from the stochastic heat equation. The additional term in the limiting equation can be interpreted as a spatial analogue to the Itô-Stratonowich correction term appearing in the usual theory of stochastic differential equations.

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MS29

On the Fluctuations of Fronts in Random Media

I will describe some asymptotic properties of reaction-diffusion fronts propagating in random media, including the fluctuations of the front position around the large-time mean behaviour.

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MS29

Waves and Particles in Slowly Decorrelating Random Media

Slow decay of correlations in random media leads to fractional limits for waves and particles in the large distance limit. I will describe some results in this direction concerning the phase of a wave in a random medium.

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MS30

Combinatorial and Parallel Programming Point of Views for Markovian Energies Minimization

Many image processing processing problems can be formulated as the minimization of a Markovian energy. In this talk, a combinatorial point of view is considered. I focus on the minimization of the Total Variation with convex data fidelity terms both from a continuous and a discrete point of view. Two algorithms are presented: a) a pure combinatorial algorithm relying on the parametric maximum-flow in a network. and b) an approximation algorithm that allows an extremely efficient parallel programming implementation. Several applications such as crystalline/mean curvature flow, deconvolution and compressive sensing reconstruction are presented.

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MS30

Existence and Regularity of Minimizers for a Multiphase Segmentation Variational Model

We consider a new functional for image segmentation which has been proposed by Sandberg, Kang and Chan. The functional is a modified version of the Mumford and Shah functional for the partition problem. In the new functional the length term of the Mumford and Shah functional is multiplied by the sum of the ratios perimeter/area of the sets of the partition. We study the regularity of boundaries of sets which constitute an optimal partition by using an existence result of minimizers for a weak version of the functional defined on the class of sets with finite perimeter. Techniques for the present problem are adapted from the analysis of the Mumford and Shah functional in the piecewise constant case.

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MS30

Analysis of a Total Variation-Based Model for Image Restoration with Higher Order Regularization

The higher order total variation-based model for image restoration proposed by Chan, Marquina, and Mulet is analyzed in one dimension. A suitable functional framework in which the minimization problem is well posed is being proposed, and it is proved analytically that the higher order regularizing term prevents the occurrence of the staircase effect. The generalized version of the model considered here includes, as particular cases, some curvature dependent functionals.

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MS30

An Extension of the Wasserstein Distance

The Wasserstein distance has been used in a variety of applications as a measure of likeness of two images. One issue in such applications is that the Wasserstein metric only measures distances between measures of the same total "mass". So the images need to be normalized, which leads to a loss of potentially useful information. Here we extend the Wasserstein distance to nonnegative measures of potentially different total mass. In particular we show from a large class of possible extensions, only a one-parameter family satisfies certain requirements which are natural for the image-processing applications.

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MS31

Entire Solutions for Biharmonic Equations with Power Nonlinearities

It is well known that the biharmonic equation $\Delta^2 u = u|u|^{p-1}$ with $p \in (1,\infty)$ has positive solutions on $\mathbf{R}^n$ if and only if the growth of the nonlinearity is critical or supercritical. We complement this result by proving the existence and uniqueness, up to scaling and symmetry, of oscillatory radial solutions on $\mathbf{R}^n$ in the subcritical case and analyzing their nodal properties.

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Paul G. Schmidt
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MS31

Nonlinear Waves in Suspension Bridges and Related Problems

I will review a series of results on travelling waves in nonlinearly suspended beams. The equation will be a nonlinearly perturbed fourth order problem on $\mathbf{R}^1$. I will cover some important open questions on the interactions and fission of these waves. Several open problems will be adressed at the end of the talk.

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MS31

Qualitative Behavior and Asymptotics of Radial Solutions for Polyharmonic Equations with Power-type Nonlinearities

We are interested in polyharmonic equations of the form $\Delta^m u = f(u)$, where m is a positive integer and f a p-homogeneous function with $p \in (1,\infty)$. A wealth of information about radial solutions can be inferred from the dynamics of the corresponding ODE $u^{(2m)} = f(u)$. We describe the technique and present detailed results for the biharmonic equation $\Delta^2 u = u|u|^{p-1}$.

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MS31

Biharmonic Equations and Domains with Corners

For one of the first boundary value problem in pde, namely $\Delta u = f$ in Ω with Dirichlet boundary conditions on $\partial\Omega$ one knows that for most nice approximations Ω_n of Ω, the corresponding solutions u_n on Ω_n converge to u. For the biharmonic problem this changes drastically. We will present some of the problems that occur when the boundary contains corners.

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MS32

A Discontinuous Galerkin Solver for Full-Band Boltzmann-Poisson Models

We present new results of a discontinuous Galerkin (DG) scheme applied to deterministic computations of the transients for the Boltzmann-Poisson (BP) system describing electron transport in semiconductor devices. In recent years, results for one and two dimensional devices were obtained in the case of silicon semiconductor assuming the non-parabolic band approximation. Here, more general band structures are considered. Preliminary benchmark numerical tests on Kane and Brunetti et al. band models are reported.

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MS32

The Discontinuous Galerkin Method for the Wigner-Fokker-Planck Equation

The Wigner-Fokker-Planck equation is a model of an open quantum system coupled to a heat bath. We have developed a discontinuous Galerkin method for computing time dependent solutions given a wide range of external potential functions. The method does not depend on a polynomial approximation space. I will discuss the method and an application to calculate the effect of grain boundaries on resistivity in small wires.

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MS32

A New Discontinuous Galerkin Method for

Hamilton-Jacobi Equations

Different to Hu-Shu's paper in 1999, we develop a local discontinuous Galerkin method to directly solve Hamilton-Jacobi equations. For the linear case, the method is equivalent to the discontinuous Galerkin method for conservation laws. Thus, stability and error analysis are valid. For both convex and nonconvex Hamiltonian, optimal (k+1)-th order of accuracy for smooth solutions are obtained with piecewise k-th polynomial approximations. The schemes are numerically tested on a variety of one and two dimensional problems. The method works well to capture sharp corners(discontinuous derivatives) and converges to the viscosity solution.

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MS33
Hyperbolic Conservation Laws on a Spacetime

We consider nonlinear hyperbolic conservation laws posed on a differential (n+1)-manifold with boundary (referred to as a spacetime) for which the "flux' is defined as a field of n-forms depending on a parameter (the unknown variable). Under a global hyperbolicity condition which implies no topological restriction on the manifold, we establish the existence and uniqueness of an entropy solution to the initial and boundary value problem. No foliation is assumed on the spacetime and a new formulation of the finite volume method based on 'total flux' functions is introduced. References: P. Amorim, P.G. LeFloch, and B. Okutmustur, Finite volume schemes on Lorentzian manifolds, Comm. Math. Sc. 6 (2008), 1059–1086. M. Ben-Artzi, J. Falcovitz, and P.G. LeFloch, Hyperbolic conservation laws on the sphere. A geometry-compatible finite volume scheme, J. Comput. Phys. (2009). J. Giesselman and P.G. LeFloch, Hyperbolic conservation laws on spacetimes with boundary, preprint 2009. P.G. LeFloch, W. Neves, and B. Okutmustur, Hyperbolic conservation laws on manifolds. An error estimate for finite volume schemes, Acta Math. Sinica (2009).

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MS33
Stability of White Dwarfs Stars

We prove existence of rotating star solutions which are steady-state solutions of the compressible isentropic Euler-Poisson (EP) equations in 3 spatial dimensions, with prescribed angular momentum and total mass. This problem can be formulated as a variational problem of finding a minimizer of an energy functional in a broader class of functions having less symmetry than those functions considered in the classical Auchmuty-Beals paper. We prove the nonlinear dynamical stability of these solutions with perturbations having the same total mass and symmetry as the rotating star solution. These results apply to white dwarf stars when the total mass is below a critical mass.

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Joel Smoller
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MS33
On the Two-dimensional Pressureless Equations

We discuss the existence of weak solutions of the 2D nonlinear pressureless equations. We develop an L1 theoretical framework for dual solutions of such equations. Their existence is realized as vanishing viscosity solutions, which follows from spectral dynamics.

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MS33
Weak Stability and Hydrodynamic Limit of Vlasov-Maxwell-Boltzmann Equations

Weak stability and hydrodynamic limit of renormalized solutions to the Vlasov-Maxwell-Boltzmann equations will be discussed.

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MS34
Estimates for the Boltzmann Collision Kernel via Analysis of an N-particle Stochastic System

In 1956, Mark Kac proposed a novel approach to the study of the Boltzmann equation via the large N limit of a stochastic system of N particle undergoing binary collisions. In the 1960's, Henry McKean and his students made many significant contributions to this program, particularly with regard to the problem of propagation of chaos. However, analysis of the rate of equilibriation for this model remained an open problem for many years, and progress on this front was much more recent. Until now, this progress has been made for what corresponds to "Maxwellian molecules". Recent work of myself, Carvalho and Loss extends this progress to the physically significant hard-sphere case. This talk will explain this result, but starting from the beginning, assuming no knowledge of Kac's program.

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MS34
On Strong Convergence to Equilibrium for the

Boltzmann Equation with Soft Potentials

The paper concerns L^1-convergence to equilibrium for weak solutions of the spatially homogeneous Boltzmann Equation for soft potentials (œB!]œ(B4œ(C!Bœ($B\gamma < 0$), with and without angular cutoff. We prove the time-averaged L 1-convergence to equilibrium for all weak solutions whose initial data have finite entropy and finite moments up to order greater than $2 + |\gamma|$. For the usual L^1-convergence we prove that the convergence rate can be controlled from below by the initial energy tails, and hence, for initial data with long energy tails, the convergence can be arbitrarily slow. We also show that under the integrable angular cutoff on the collision kernel with œB!]œ(B1œ(C!Bœ($B\gamma < 0$, there are algebraic upper and lower bounds on the rate of L^1-convergence to equilibrium. Our methods of proof are based on entropy inequalities and moment estimates. This is joint work with E. A. Carlen and Xuguang Lu.

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MS34
Vanishing Diffusion Limit for the Coagulation Equation

Abstract not available at time of publication.

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MS34
Global Small Solutions of a Micro-macro Models for Polymeric Fluids Near Local Equilibrium

Abstract not available at time of publication.

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MS35
The Stefan Problem with Anisotropic Gibbs Thomson Law: Analysis and Numerical Approximation

The Stefan problem with Gibbs-Thomson law models solidification phenomena such as dendritic growth. In my talk I will present a global existence result in situations where the Gibbs-Thomson law is anisotropic. In a second part of my talk I will discuss a novel stable finite element discretization of the Stefan problem with anisotropic Gibbs Thomson law. Finally I will show several numerical computations including dendritic growth and facetted growth.

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MS35
Some New Nonlocal Diffusions with Application to Image Processing

After a brief historical perspective on the use of nonlinear diffusion in image processing, some novel equations will be introduced which are characterized by a non-local dependence in the diffusivity via fractional derivatives. The new models are well-posed but still allow for non-trivial dynamical behavior as desired in their application to performing image processing tasks. Theoretical and experimental results will be presented.

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MS35
The Matching and Density Properties of Infinitesimal Isometries of Convex Surfaces, with Applications to Nonlinear Elasticity of Shells.

We shall discuss the density of smooth infinitesimal isometries in the space of $W^{2,2}$ first order infinitesimal isometries, and matching smooth infinitesimal isometries with exact isometric immersions on smooth elliptic surfaces. We shall point to our major application, which is deriving the limiting behavior of the 3d nonlinear elastic energy for thin elliptic shells, as their thickness h converges to zero, under the assumption that the elastic energy of deformations scales like h^β with $\beta > 2$. Namely, contrary to the case of plates, for the given scaling regime, the limiting theory reduces to the linear pure bending.

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MS35
Crystal Surface Diffusion: Numerical Simulation and Homogenization

Models of surface diffusion on crystals mainly invoke: (i) a singular interfacial energy E; (ii) Fick's law relating flux and the variational derivative of E; and (iii) a conservation law for the graph. In the first part of my talk, I will present progress and puzzles in simulating surface evolution by the Finite Element Method in 2+1 dimensions. In the second part, I will address the derivation of (ii) from microscopic models in the case of a surface composite.

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MS36
Trapping of Quasigeostrophic Waves in the Equatorial Shallow Water Equations

In this talk we shall discuss a joint work with Ch. Cheverry, Th. Paul and L. Saint-Raymond showing that the shallow water flow, subject to strong wind forcing and linearized around an adequate stationary profile, develops for large times closed trajectories due to the propagation of Rossby waves, while the Poincaré waves are shown to disperse. The techniques used to prove that result involve semi-classical analysis and spectral methods.

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MS36
Title Not Available at Time of Publication

Abstract not available at time of publication.

Theodore Tachim-Medjo
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MS36
A One Parameter Family of Expanding Wave Solutions of the Einstein Equations that Induces an Anomalous Acceleraton into the Standard Model of Cosmology

I introduce a new family of general relativistic expanding wave perturbations of the Standard Model of Cosmology, and explore the possibility that they can account for the Anomalous Acceleration of the galaxies within classical General Relativity, without the need for Dark Energy or the Cosmological Constant. [Joint work with Joel Smoller.]

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MS36
Stable Directions for Degenerate Excited States of Nonlinear Schrödinger Equations

We consider the nonlinear Schrödinger quations $i\partial_t\psi = H_0\psi + \lambda|\psi|^2\psi \in R^3 \times [0,\infty)$ where $H_0 = \Delta + V$ and $\lambda = \pm 1$. Our potential V, decays sufficiently fast at infinity. The linear Hamiltonian H_0 has two discrete eigenvalues, one simple and one of multiplicity three. We show that there exist three branches of nonlinear excited states and for certain finite codimension subset in the space of initial data, we construct solutions converging to these excited states in both non-resonant and resonant cases.

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MS37
Existence and Stability of Fully Localised Three-dimensional Gravity-capillary Solitary Water Waves

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

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

subject to the constraint that the impulse

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

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

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MS37
The Pressure Beneath a Steady Water Wave

A Stokes wave is a irrotational incompressible periodic 2D steady water wave under the influence of gravity. It is well-known that there is a one-parameter family of such waves. I will prove that the pressure in the fluid strictly increases both (i) with depth and (ii) horizontally toward the crest line. Numerical evidence shows that this is not necessarily true in the presence of vorticity.

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MS37
Existence and Stability of Solitary Water Waves with Weak Surface Tension

We prove that two-dimensional solitary water waves with weak surface tension can be constructed by minimising the energy subject to the constraint of fixed momentum. The proof relies on the concentration-compactness method and the main difficulty is to prove that the infimum of the energy is a strictly sub-additive function of the momentum. This is done by a careful analysis of a certain minimising sequence. The resulting solutions are periodic wave trains modulated by exponentially decaying envelopes and the fact that they are constrained minimisers guarantees some kind of stability. This is a joint work with Mark Groves (Saarbrcken).

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MS37
Stratified and Steady Water Waves

We will discuss two-dimensional, periodic, stratified, traveling water waves propagating over an impermeable flat bed and with a free surface. The wave's motion is assumed to be driven by surface tension on the upper boundary and a gravitational force acting on the body of the fluid. Such waves are commonly seen to form when, for example, a wind blows over a quiescent body of water. We shall present some new results on the existence of global continua of classical solutions of this type. In the process, we shall also answer some open questions for the constant density case.

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MS38
Eddy Current Problems: Different Choices of the

Main Unknown in the Conductor and the Insulator

The typical setting for an eddy current model distinguishes between a bounded conducting region and its complement, the air region. A fundamental difference of the eddy current model and the full Maxwell's is the broken symmetry between the electric and the magnetic field in the air region. We will discuss the different variational problems that emerge by retaining either **E** or **H** as principal unknown, and their finite element approximation.

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MS38

Automatic Coupling and Finite Element Discretization of the Navier-Stokes and Heat Equations

Abstract not available at time of publication.

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MS38

Finite Elements for the Immersed Boundary Method and Added-mass Effect

We review a finite element version for the *Immersed Boundary Method*, designed by Peskin for the modeling and the numerical approximation of fluid-structure interaction problems. The finite element version offers interesting features for the analysis of the problem, the robustness and flexibility of the numerical scheme. We present a stability analysis showing that the time-step and the discretization parameters are linked by a CFL condition, independently of the ratio between the densities of fluid and solid.

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MS38

Coupling of Eddy Current and Circuit Problems

Eddy current equations are a reduced model used in electromagnetism when the frequency is small. It can be seen as a coupled problem, where coupling takes place through the interface between a conductor and its complement. We present a new formulation of the eddy current equations in terms of the electric field in the conductor and the magnetic field in the insulator, and we use it for facing the problem of coupling with circuits.

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MS39

Mathematical Models for Urban Crime

Motivated by empirical observations of spatio-temporal clusters of crime across a wide variety of urban settings, we present a model to study the emergence, dynamics, and steady-state properties of crime hotspots. This talk focuses on a two-dimensional lattice model for residential burglary, where each site is characterized by a dynamic attractiveness variable, and where each criminal is represented as a random walker. The dynamics of criminals and of the attractiveness field are coupled to each other via specific biasing and feedback mechanisms. Depending on parameter choices, the model has several regimes of aggregation, including hotspots of high criminal activity. I also discuss the model and related models in the context of real data from the Los Angeles Police Department and Long Beach Police Department.

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MS39

Stochastic Shell Models and Their Statistical Properties

We will define some stochastic shell models and their relationship with the 3D Navier-Stokes equations. We will prove the well posedness of the models and study their longtime behavior such as invariant measures. Moreover, we will introduce a linear version of the Shell model and study its statistical properties and relationship with the nonlinear model.

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MS39

Existence, Uniqueness and Statistical Theory of the Stochastic Navier-Stokes Equation in Three Dimensions.

We will discuss the existence of unique rough solutions of the Navier-Stokes equation in three dimensions. These solutions are the result of noise that the equation produces at high Reynolds numbers. They also give a unique invariant measure that permits the development of Kolmogorovs statistical theory of turbulence.

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MS39

Renormalization and Rescaling of Elliptic SPDEs with Gaussian Coefficients

In many SPDEs with stochastic coefficients, modeling randomness by spatial white noise may lead to ill-posed problems. We will consider an elliptic problem with spatial Gaussian coefficients and present a methodology that resolves this issue. It is based on stochastic convolution implementation via generalized Malliavin operators in conjuncture with weighted Wiener Chaos expansions that resolves the ellipticity issue. The talk is based on joint work with S. Lototsky and X. Wan

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MS40

Kinetic Approaches in Mesoscale Modeling of Polycrystals

Polycrystalline materials are important in many technological applications, yet there are still many challenges they present for mathematical modeling and analysis. One such challenge lies in understanding how statistical distributions develop in the process of coarsening of materials microstructure and how these distributions in turn relate to materials properties. In this talk, we will discuss and compare several recent continuum level models resulting in nonlinear evolution equations. Special focus will be placed on newly discovered features of interface dynamics that connect this problem to the theory of nonhomogeneous Poisson processes and Boltzmann equations. Numerical and analytical characteristics of the solutions will be discussed and compared against the results produced by experiments and large-scale simulations.

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MS40

Bounds on Rate of Coarsening in Grain-boundary Networks

Boundaries between grains in polycrystalline materials can evolve to reduce the interfacial energy. For example, if the energy is isotropic the grain boundary network moves with velocity equal to the mean curvature (with appropriate conditions at interface junctions). The evolution leads to coarsening of the network: the number of grains decreases, while the average grain size grows. I will present mathematical results on the rate at which the coarsening occurs. In particular, an upper-bound on coarsening rate which is rigorous under some structural assumptions on the network. The results will also be presented for a simplified vertex model. Numerical experiments that support the conjecture that the upper bound is optimal will also be shown. The talk is based on joint work with Eva Eggeling and Shlomo Ta'asan.

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MS40

Low-Angle Grain Boundary Mobility in a Dislocation Dynamics Framework

We investigated the migration of a symmetric tilt, low-angle grain boundaries (LAGB) under an applied shear stress in the presence of extrinsic dislocations within a dislocation dynamics model. The results demonstrate that there is a threshold stress for the LAGB to depin from extrinsic dislocations. Below the threshold stress, the LAGB remains immobile at zero dislocation climb mobility, while for finite climb mobilities, it migrates at a velocity that is directly proportional to the applied stress, with a proportionality factor that is a function of misorientation, dislocation climb mobility and extrinsic dislocation density. We derive analytical expressions for the LAGB mobility and threshold stress for depinning from extrinsic dislocations. The analytical prediction of the LAGB mobility is in excellent agreement with the simulation as well as experimental results. We discuss the implications of these results for understanding the migration of general grain boundaries.

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MS40

Kinetic Theories for Complex Fluids

Kinetic theory is a powerful tool to formulate hydrodynamic models for complex fluids and soft matter material systems. It can provide much needed insight into the model at multiple length scales and even time scales. In this talk, I will present a framework for multicomponent complex fluid mixtures to study polymer blends, polymer-particulate nanocomposites, and biofilm flows. Spatial inhomogeneity of the complex fluid systems can be modeled effectively through translational diffusion and nonlocal and long range molecular interactions. Analytical analysis in limiting cases and numerical examples will be presented to show the effectiveness of the kinetic theory modeling.

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MS41

A Variational Model for Denoising Surfaces in Computer Graphics Applications

Geometry denoising, also known as surface fairing, is an important problem in computer graphics. It is needed whenever 3D objects are digitized and represented as triangulated surfaces, typically by sampling points from the surface of an object using a 3D scanner. Measurement errors (noise) in coordinates of the sampled points inevitably lead to oscillations in the digitized surface, giving it a rough and unnatural appearance. The goal of surface fairing is to smooth out the oscillations that are due to noise without also rounding out "legitimate" singularities such as creases and corners that are comonly found on man-made objects (such as machine parts). We will describe a new variational model for surface fairing that is the natural geometric analogue of an image processing model due to Rudin, Osher, and Fatemi. Gradient descent for the energy that we propose, which is defined on surfaces, leads to an interesting new geometric motion that removes the noise but keeps creases and corners intact as it evolves a surface. Its numerical implementation (discretization) using triangulated surfaces turns out to be quite tricky; to accomplish this task, we rely on important previous work of geometers who were interested in extending certain classical theorems from smooth to polyhedral surfaces.

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MS41

Geodesics in Shape Space via Variational Time Discretization

In the talk a variational approach to defining geodesics in the space of implicitly described shapes is introduced. The proposed framework is based on the time discretization of a geodesic path as a sequence of pairwise matching problems, which is strictly invariant with respect to rigid body motions and ensures a 1-1 property of the induced flow in shape space. For decreasing time step size, the proposed model leads to the minimization of the actual geodesic length, where the Hessian of the pairwise matching energy reflects the chosen Riemannian metric on the shape space. Considering shapes as boundary contours, the proposed shape metric is identical to a physical dissipation in a viscous fluid model of optimal transportation. If the pairwise shape correspondence is replaced by the volume of the shape mismatch as a penalty functional, for decreasing time step size one obtains an additional optical flow term controlling the transport of the shape by the underlying motion field. The implementation is based on a level set representation of shapes, which allows topological transitions along the geodesic path. For the spatial discretization a finite element approximation is employed both for the pairwise deformations and for the level set representation. The numerical relaxation of the energy is performed via an efficient multi–scale procedure in space and time. Examples for 2D and 3D shapes underline the effectiveness and robustness of the proposed approach.

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MS41

Inverse Free-Discontinuity Problems and Iterative Thresholding Algorithms

The minimization of non-convex functionals having quadratic data-fidelity term and truncated quadratic regularization have been used frequently in inverse problems related to image processing, most notably in the areas of inpainting and image segmentation. The so- called Mumford-Shah functional is perhaps the most well-known of this type; such problems in general are known as free-discontinuity problems. Despite several successful numerical results, no rigorous results on the existence of minimizers, let alone on the convergence to such minimizers, are currently available in the literature. In this talk, we show that one cannot hope for better results in the general case, showing that free-discontinuity problems are NP hard. We nevertheless introduce an iterative thresholding algorithm that is guaranteed to converge to local minimizers of such functionals; through this algorithm, we shed light on certain properties of minimizers, including a “gap” property that corroborates the cartoon- like nature of images reconstructed using free-discontinuity type minimization. Finally, we explain how free-discontinuity problems can be viewed as a relaxation of the sparse recovery problem in compressed sensing.

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MS41

Variational Methods in Hyperspectral Image Processing

Variational and PDE methods have been successfully applied to a wide range of problems for processing color images, but there has been little work extending these methods to higher dimensional imagery. A hyperspectral image typically contains hundreds of image bands, each corresponding to a precise wavelength of light. Each pixel in the image is a signal which can be used to identify the materials in the image, often with much greater accuracy than a color image could provide. Due to the nature of hyperspectral data, their usage is much different from standard color images and this gives rise to a different set of image processing problems. We will present recent work applying variational methods to the problems of spectral unmixing and image fusion, with an emphasis on the Split Bregman iterative method used for fast numerical minimization.

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MS42

Layered Superconductors in Nearly Parallel Magnetic Fields

We consider minimizers or stable solutions of the Lawrence-Doniach energy for three-dimensional layered (anisotropic) superconductors in parallel or nearly parallel magnetic fields used to model a large class of high-temperature superconducors. We find that the lower critical field becomes arbitrarily large as the field becomes nearly parallel to the layers, and we obtain upper and lower bounds on its value. We analyze the qualitative behavior of stable minimizers in nearly parallel magnetic fields in the regime of small Josephson constants, and compare with that of nonlayered superconductors given by minimizers of the three-dimensional anisotropic Ginzburg-Landau model.

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MS42

Small Volume Fraction Gamma-limits for a Nonlocal Cahn-Hilliard Functional

We discuss the small volume fraction limit of a nonlocal Cahn-Hilliard functional introduced to model microphase separation of diblock copolymers. In particular, we address the limit in which the volume fraction tends to zero but the number of minority phases (called *particles*) remains $O(1)$. Using the language of Γ-convergence, we focus on two levels of this convergence, and derive first and second order *effective* energies, whose energy landscapes are simpler and more transparent. These limiting energies are only finite on weighted sums of delta functions, corresponding to the concentration of mass into 'point particles'. At the highest level, the effective energy is entirely local and contains information about the structure of each particle but no information about their spatial distribution. At the next level we encounter a Coulomb-like interaction between the particles, which is responsible for the pattern formation. We present the results in three dimensions.

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MS42

Thin Film Limits for Ginzburg-Landau with Strong Applied Magnetic Fields

We study thin-film limits of the full three-dimensional Ginzburg-Landau model for a superconductor in an applied magnetic field oriented obliquely to the film surface. We obtain $\Gamma-$convergence results in several regimes, determined by the asymptotic ratio between the magnitude of the parallel applied magnetic field and the thickness of the film. Depending on the regime, we show that there may be a decrease in the density of Cooper pairs. We also show that in the case of variable thickness of the film, its geometry will affect the effective applied magnetic field, thus influencing the position of vortices.

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MS42

Vortex Density Models in 3 Dimensions

In this paper we consider the asymptotic behavior of the Ginzburg-Landau functional in 3-d, and we derive a limiting functional, in the sense of Gamma-convergence, in various energy regimes. We derive applications to superconductivity and Bose-Einstein condensation: a general expression for the first critical field (for superconductivity) and the first critical rotational forcing (for Bose-Einstein condensation), and the curvature equation for the vortex lines.

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MS43

Sharp Energy Estimates for Fractional Diffusion Equations

In this talk, I will mainly describe recent results in collaboration with Eleonora Cinti (Barcelona and Bologna) concerning elliptic nonlinear equations with fractional diffusion. In a work in collaboration with Y. Sire (Marseille), we studied the equation $(-\Delta)^{\alpha} u = f(u)$ in $\mathbf{R}^n$ with $\alpha \in (0,1)$. Crucial to our analysis is a result of Caffarelli-Silvestre which allows to realize this nonlocal equation as a degenerate elliptic equation in $\mathbf{R}^{n+1}_{+}$ together with a nonlinear Neumann boundary condition on $R^n = \partial \mathbf{R}^{n+1}_{+}$. We characterized the nonlinearities f for which there exists a layer solution —meaning, essentially, a solution increasing in one direction. We also established several properties of these solutions, such as their uniqueness and decay at infinity in $\mathbf{R}$, minimality in $\mathbf{R}^n$, and 1D symmetry in $\mathbf{R}^2$. In a more recent work in collaboration with E. Cinti, we establish the optimal energy estimates for minimizers, layer solutions, and also other solutions such as saddle-shaped solutions. These estimates allow to prove in $\mathbf{R}^3$ the 1D symmetry result of De Giorgi type for the nonlocal equation, previously only known in $\mathbf{R}^2$.

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MS43

Fractional Laplacian in Conformal Geometry

The fractional Laplacian a non-local, fractional order operator. We explore the relations with conformal geometry, in particular, scattering theory of conformally compact Einstein manifolds. We consider a fractional order Paneitz-type operator and its associated curvature, and try to find their geometrical implications.

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MS43

Regularity Results for Elliptic Nonlocal Equations

Abstract not available at time of publication.

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MS43

Non-local Phase Transitions

I will describe some symmetry results for solutions of equations involving the fractional laplacian. As an important step, I will explain how to construct the one-dimensional profile and study its properties such as uniqueness, asymptotic behaviour.

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MS44

Strong Solutions to Viscoelastic Fluids and Liquid Crystals

The existence and uniqueness of the strong solutions with small data to the three-dimensional viscoelastic fluids and liquid crystals will be discussed.

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MS44

Title Not Available at Time of Publication

The complex fluids posses the properties of both the fluids and solids. The relative strength of the each effects is reflected through the "relative" magnitude of the Reynolds number and the Weissenberg number. While the Reynolds number represent the "viscous" dissipation of the fluids, the Weissenberg number represents the elastic dissipation (relaxation). Sometime, the constant is identified/confused to be the Deborah number. The cases of infinite Reynolds number and infinite Weissenberg number are in fact identical to the pure elasticities. Moreover, there are many physical and rheological situations can be modeled/formulated in large/high Weissenberg number problems. From PDE point of view, the system will demonstrate more properties of hyperbolic wave equation in cases of large/infinite Weissenberg number. This present major challenges and difficulties in both analysis and numerical simulations. Most well-established work in mathematics have been in the area of fluid dominate region (with small Weissenberg number). High Weissenberg number problems are also present in wide range of applications, such as the benchmark problems of flow through contraction, flow past a cylinder, micromixing, as well as in MHD, where in many cases (such as the modeling of the Sun), the magnetic diffusion can be mostly neglected. The problem is closely related/conjectured to the elastic turbulence phenomena. In the situations with large/infite Weissenberg number, the total system is still dissipative (due to the fluid viscosity). Mathematically, this is a partial dissipative system, where most of the established analysis and numerical tools fail. In fact, even the global existence of the energy solutions (Leray's solution) is still an open problem. Recently, we succeed to prove the global existence of the classical solution with small initial data. The proof relied heavily on the energetic variational structure of the system, in particular, the coupling between the induced elastic stress and the kinematic transport of the elastic variable. From the mathematical point of view, the system can be derived from the energetic variational approach framework. Energetically, there is the competition between the kinetic energy and the elastic energy. The competition is through the kinematic transport, which (after the various variational procedures) gives the induced elastic stresses, such as the Maxwell stress in MHD and the elastic stresses in the viscoelatic fluids. All analysis and the numerics need to preserve these structures (the kinematic transport, as well as the variational structure), especially when the solutions involve singularities or pattern/structures.

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MS44

Hyperbolic Balance Laws

Hyperbolic balance laws arise naturally in continuum physics, elasticity and other applied fields. In this talk recent developments in hyperbolic balance laws are presented. Sharp decay estimates are derived for the positive waves in an entropy weak solution to a class of hyperbolic balance laws. The result is obtained by introducing a partial ordering within the family of Radon measures and a comparison with a solution of Burgers's equation with impulsive sources. An application and further consequences will be discussed.

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MS44

Nonlinear Stability of Non-isentropic Conical Flows Past a Perturbed Cone with Large Angle

In [Wen-Ching Lien, Tai-ping Liu, Nonlinear Stability of a Self-Similar 3-Dimensional Gas Flow], the authors proved that the 3-d supersonic gas flow past an infinite cone with very small vertex angle was globally stable. We are interested in the case when the vertex angle was large so that the strong shock issuing from the tip of the cone is no longer negligible, we analyze, in particular the wave interaction between the strong shock and local weak waves, and constructed a globally decreasing Glimm-type functional to finally establish the stability of the strong shock structure.

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MS45

Sharp-Interface Models for Fluidic Particles

Sharp-interface models for two-phase flows allow different levels of physico-chemical interface properties, starting from a purely geometric dividing interface to the case when the interface is a phase for itself with surface viscosity and variable surface tension - the so-called Boussinesq-Scriven surface fluid. For the different levels of interfacial properties, the corresponding models together with main analytical results are outlined. Some results of VOF-based numerical approaches are also included.

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MS45

Fingering Patterns for the Muskat problem

Of concern is the study of a free boundary problem describing the flow of a two-phase flow in a Hele-Shaw cell. The less dense fluid is located in the bottom part of the cell. The free boundary separating the fluids moves under the influence of surface tension and gravity. The existence of nontrivial stationary fingering patterns is proved for a null sequence of surface tension coefficients. These fingers appear as global bifurcation branches from the trivial flat stationary solution

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MS45

Vanishing Viscosity Limit of the One-dimensional Navier-Stokes Equations to the Euler Equations

We establish the vanishing viscosity limit of the one-dimensional Navier- Stokes equations to the isentropic Euler equations. For the Navier-Stokes equations, the sup-norm of solutions can not be controlled since there exist no natural invariant regions for the equations with the physical viscosity term and, furthermore, convex entropy-entropy flux pairs may not produce a signed entropy dissipation measures. To overcome these difficulties, we first develop uniform energy-type estimates with respect to the viscosity coefficient for the solutions to the Navier-Stokes equations and establish the existence of measure-valued solutions to the isentropic Euler equations generated by the Navier-Stokes equations. Based on the uniform energy-type estimates and special features of the isentropic Euler equations, we establish that the entropy dissipation measures of the Euler equations for the solutions to the Navier-Stokes equations for weak entropy-entropy flux pairs are contained in a compact set in H^{-1} which leads to the div-curl commutator relation for the corresponding measure-valued solutions, determined by the vanishing viscosity sequence of solutions. A careful characterization of the unbounded support of the measure-valued solutions yields the reduction of the measure-valued solutions to a Delta mass, which lead to the convergence of the finite-energy solutions of the Navier-Stokes equations to a finite-energy entropy solution to the isentropic Euler equations.

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MS45

On the Rayleigh-Taylor Instability for the Two-phase Navier-Stokes Equations

We consider the motion of two superposed immiscible, viscous, incompressible, capillary fluids that are separated by a sharp interface which needs to be determined as part of the problem. Allowing for gravity to act on the fluids, we prove local well-posedness of the problem. In particular, we obtain well-posedness for the case where the heavy fluid lies on top of the light one, that is, for the case where the Rayleigh-Taylor instability is present. Additionally we show that solutions become real analytic instantaneously, and we give a rigorous proof of the Rayleigh-Taylor instability.

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MS46

Steady-state Navier-Stokes Flows with Rough External Forces

We address the existence, the asymptotic behavior and stability in L^p and $L^{p,\infty}$, $\frac{3}{2} < p \leq \infty$, for solutions to the steady state 3D Navier-Stokes equations with possibly very singular external forces. We show that under certain smallness conditions of the forcing term there exists solutions to the stationary Navier-Stokes equations in L^p spaces, and we prove the stability of these solutions as fixed points of the non-stationary Navier–Stokes. The non-stationary solutions can be large. We also give non-existence results of stationary solutions in L^p, for $1 \leq p \leq \frac{3}{2}$. This is a joint work with Clayton Bjorland, Dragoş Iftimie and Maria Schonbek

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MS46

Delayed Navier-Stokes Equations in $\mathbf{R}^2$: Existence and Decay of Global Solutions

We prove global existence and uniform decay of the L^2 norm of solutions to the $2D$ Navier-Stokes equations when the external force contains a delay term, i.e. one that depends on the values of the solution $\mathbf{u}$ at past times.

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MS47

Stability of Co-propagating N-solitons of FPU Lattices in the KdV Limit

Solitary waves of the FPU lattices cannot be characterized as a critical point of conservation due to the lack of infinitesimal invariance in the spatial variable. I prove an exponential stability property of the linearized FPU equation around an N-soliton in a weighted space which is biased in the direction of motion and prove stability of N-soliton solutions in the energy space.

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MS47

On Spectral Stability for Small Solitary Water Waves

I will discuss a draft proof (with Shu-Ming Sun) of spectral stability of small solitary waves for the 2D Euler equations for water of finite depth without surface tension.

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MS47

Nonlinear Instability of Periodic Travelling Waves for a 1D Boussinesq System

We build periodic travelling wave solutions of the nonlinear one-dimensional Boussinesq system $q_t = r_x$, $r_t = B^{-1}(Aq_x - 2rq q_x - 2q^2 q_t)$, where $A = I - a\partial_x^2$ and $B = I - b\partial_x^2$. We discuss orbital instability of these solutions and we provide numerical evidence on a type of instability arising when perturbing with small amplitude disturbances. Orbital instability of periodic travelling waves for wave speed $1 < c < \sqrt{a/b}$ is obtained by adapting a theory of Grillakis, Shatah and Strauss, or work of Bona, Souganidis and Strauss for KdV-type equations.

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MS47

Counterpropagating Two-soliton Solutions in the FPU Lattice

I will describe how one can construct asymptotic two-soliton solutions for the Fermi-Pasta-Ulam model with general interaction potential. These are solutions whose difference from the linear superposition of two solitary waves goes to zero as time goes to infinity, with no residual radiation. This is joint work with Aaron Hoffman of Boston University.

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MS48

How to Best Approximate a Fully Viscous Solution with Inviscid Approximations in Subregions

In many applications, viscous terms are not important in large parts of the computational domain, and one would like to solve a cheaper inviscid problem there instead. We show in this talk that for the model problem of advection reaction diffusion equations, there are coupling conditions based on the factorization of the operator, which lead to approximate solutions much closer to the fully viscous one than with classical coupling conditions from the literature.

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MS48

Weak Coupling Between Scales and Models: A Frequency Oriented Approach for Transferring Information in Heterogeneous Models

The coupling of models on different scales (e.g. molecular dynamics/continuum mechanics) is a source for heterogeneities in (discrete) models. The information transfer between the models requires some "filtering' of the passed information: only the information usable in both interfacing models should be transferred, thus avoiding spurious effects. In this talk, we present a new frequency oriented coupling concept for concurrent multiscale simulations and will discuss its relation to existing coupling concepts for finite element discretizations.

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MS49

Crossover in Coarsening Rates for the Monopole Approximation of the Mullins-Sekerka Model with

Kinetic Drag

The Mullins-Sekerka sharp-interface model for phase transitions interpolates between attachment-limited and diffusion-limited kinetics if kinetic drag is included in the Gibbs-Thomson interface condition. Heuristics suggest that the typical length scale of patterns may exhibit a crossover in coarsening rate from $l(t) \sim t^{1/2}$ at short times to $l(t) \sim t^{1/3}$ at long times. We establish rigorous, universal one-sided bounds on energy decay that partially justify this understanding in the monopole approximation and in the associated LSW mean-field model. Numerical simulations for the LSW model illustrate the crossover behavior.

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MS49

Aspects of Coarsening in Microstructural Evolution

Coarsening during microstructural evolution has many features which appear to be driven by different mechanisms. Some of these are transport related while others are more easily described as entropic. What sort of models can we derive to present the array of phenomena and what mathematical questions do they pose?

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MS49

A Continuum Model for Selectivity Mechanism in Ion Channels: An Energetic Variational Approach

The interactions of ions flowing through biological systems has been a central topic in biology for more than 100 years. Flows of ions produce signaling in the nervous system, initiation of contraction in muscle, coordinating the pumping of the heart and regulating the flow of water through kidney and intestine. Ion concentrations inside cells are controlled by ion channels through the lipid membrane. In this talk, I will propose a continuum model that is derived from the energetic variational approach which include the coupling between the electrostatic forces, the hydrodynamics, diffusion and crowding (due to the finite size effects). The model provides some basic understanding of one of the most important properties of proteins, the ion selectivity. This is a joint work with Yunkyong Hyon (IMA), Taichia Lin (National Taiwan University) and Robert Eisenberg (Rush Medical School).

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MS49

Kinetic Descriptions of Evolution of Crystalline Surfaces

The evolution of crystalline surfaces is often described via particle-type equations for line defects (steps) at the nanoscale. In this talk, I will focus on challenges encountered and recent progress made in extracting mesoscale and macroscale descriptions of surface evolution by methods of kinetic theory. I will discuss the role of step correlation functions and their hierarchies in stochastic settings. The kinetic approach reveals useful analogies with other physical systems such as non-uniform liquids.

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MS50

Optimal Estimates for Semilinear Elliptic Equations

In this work we study the distribution function of the solutions to the Dirichlet problem

$$\begin{cases} -\Delta_p u = f(u) & \text{in } \Omega \\ u > 0 & \text{in } \Omega \\ u = 0 & \text{on } \partial\Omega, \end{cases} \tag{2}$$

where Ω is an open bounded set of $\mathbf{R}^n$ and f is a nonnegative Lipschitz function with a suitable growth. Our main concern is to compare the distribution function of a solution associated to Ω with the maximal one associated to the ball B with same measure, obtaining results similar to some Talenti estimates. We get also some estimates for general domains. We apply these results to estimate the maximum of an eigenfunction by its L^2 norm and by the corresponding eigenvalue.

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MS50

Remarks on Aleksandrov-Bakelman-Pucci Maximum Principle, Weak Harnack Inequality and Their Consequences

Aleksandrov-Bakelman-Pucci (ABP) maximum principle and Harnack inequality are classical tools in the theory of elliptic PDE and in the last two decades these topics have been revisited for fully nonlinear uniformly elliptic equations from the point of view of viscosity solutions. We will discuss old and new results and show when the ABP maximum principle is true for equations with superlinear growth in the gradient (in which case it has been known to fail in general). Moreover we will present a small recent improvement in weak Harnack inequality for fully nonlinear equations. As a consequence we will show how these techniques allow to obtain new results about solvability of nonlinear PDE, in particular of certain Pucci extremal equations.

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MS50

Estimates the Solutions of Free Boundary Problems

This is a joint work with Diego Moreira, where we will estimate the Hausdorff measure of the free boundary of general fully nonlinear elliptic equations.

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MS50

Some Results About the Uniqueness of Infinity Ground States

It was proved by Juutinen, Lindqvist and Manfredi that asymptotic limits of principle eigenfunctions of p-Laplacian operators are viscosity solutions of a free boundary problem, i.e, the so called ?nfinity ground states? A very interesting question is whether the infinity ground state is simple. In this talk, we will discuss some results related to this uniqueness issue.

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MS51

Existence, Stability, and Regularity of Global Solutions to Shock Reflection Problems, Part I

In these two talks, we will discuss our recent results on shock reflection problems for the potential flow equation. We will start with discussion of shock reflection phenomena. Then we will describe the results on the existence and stability of global solutions to regular shock reflection for all wedge angles up to the sonic angle, as well as on the regularity near the sonic arc (joint work with M. Bae). The approach is to reduce the shock reflection problem to a free boundary problem for a nonlinear elliptic equation, with ellipticity degenerate near a part of the boundary (the sonic arc). We will discuss techniques to handle such free boundary problems and degenerate elliptic equations. Furthermore, some related multidimensional shock problems and further developments in this direction will be also addressed.

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MS51

Non-uniqueness of Inviscid Flows

We report on several recent results on non-uniqueness of the Cauchy problem for the incompressible and compressible Euler equations. The consequences for theory and numerics, and the relation to physically observed phenomena, will be discussed in detail.

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MS51

Existence, Stability, and Regularity of Global Solutions to Shock Reflection Problems, Part II

In these two talks, we will discuss our recent results on shock reflection problems for the potential flow equation. We will start with discussion of shock reflection phenomena. Then we will describe the results on the existence and stability of global solutions to regular shock reflection for all wedge angles up to the sonic angle, as well as on the regularity near the sonic arc (joint work with M. Bae). The approach is to reduce the shock reflection problem to a free boundary problem for a nonlinear elliptic equation, with ellipticity degenerate near a part of the boundary (the sonic arc). We will discuss techniques to handle such free boundary problems and degenerate elliptic equations. Furthermore, some related multidimensional shock problems and further developments in this direction will be also addressed.

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MS51

Entropies for Hyperbolic Systems with Prescribed Eigenfields

Consider the following problem: given n linearly independent vector fields on an open subset of $\mathbf{R}^n$ - when is it possible to find a hyperbolic system of n conservation laws $u_t + f(u)_x = 0$ such that the flux f has eigenfields equal to the given vector fields? This problem has been analyzed by the authors in a previous work. We now add the constraint that the resulting system should be equipped with a non-trivial entropy. We provide a self-contained formulation of this problem (i.e. entirely in terms of the given vector fields) where the unknowns are the eigenvalues of the Hessian of the entropy. The resulting overdetermined system for these eigenvalues will be derived and we discuss its solvability. Various examples will be considered.

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MS52

Blow-up in Multidimensional Aggregation Equations with Mildly Singular Interaction Kernels

I will discuss recent results for the multidimensional aggregation equation $u_t - \nabla\cdot(u\nabla K * u) = 0$ in which the radially symmetric attractive interaction kernel has a mild singularity at the origin (Lipschitz or better). Under mild monotonicity assumptions on the kernel K, the Osgood condition for well-posedness of the ODE characteristics is a necessary and sufficient condition for global in time well-posedness of the PDE with compactly supported bounded nonnegative initial data in all dimensions. I also discuss the case of data in L^p for which the same condition also determines local vs. global-in time well-posedness for p larger than a critical value, depending on the potential. I also present some numerical computations illustrating that the L^p problem is important for finite time blowup and some examples that illustrate that the equation is not locally well-posed in L^p for subcritical p. This is joint work with Thomas Laurent, Jose Carrillo, Jesus Rosado, and Yanghong Huang.

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MS52

A Harnack-type Estimate for Subcritical Singular Parabolic Equations

For non-negative solutions of quasilinear singular parabolic equations of p-laplacian type a novel intrinsic Harnack estimate is established and its relation to Holder continuity is traced.

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MS52

Symmetry Properties of Positive Solutions to Parabolic Problems

Symmetry properties of non-negative bounded solutions of fully nonlinear parabolic equations on bounded reflectionally symmetric domains with Dirichlet boundary conditions will be studied. A sufficient conditions on the equation and domain, which guarantee asymptotic symmetry of solutions will be given. The basic techniques include the method of moving hyperplanes, maximum principles and Harnack inequalities.

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MS52

Mean Value Theorems for Nonlinear PDEs

In this talk we present a characterization of viscosity solutions to a class of nonlinear parabolic equations in terms of an asymptotic mean value property. The corresponding elliptic problem was considered in [J.J. Manfredi, M. Parviainen, and J.D. Rossi. An asymptotic mean value characterization for p-harmonic functions]. This is a joint work with J.J. Manfredi and J.D. Rossi.

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MS53

Classical Solutions and Stability Results for the Boltzmann Equation

This talk focuses on the study of existence and uniqueness of distributional and classical solutions to the Cauchy Boltzmann problem for the soft potential case assuming S^{n-1} integrability of the angular part of the collision kernel (Grad cut-off assumption). We study the propagation of regularity using a recent estimate for the positive collision operator given by E. Carneiro and the authors, that permits to study such propagation without additional conditions on the collision kernel. Finally, an L^p-stability result (with $1 \leq p \leq \infty$) is presented assuming the aforementioned condition.

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MS53

The Dynamics of Viral Entry

Successful viral infection of a healthy cell requires complex host-pathogen interactions. In this talk we focus on the dynamics specific to the HIV virus. We model viral entry as a stochastic engagement of receptors and coreceptors on the cell surface. We also consider the transport of virus material to the cell nucleus by coupling microtubular motion to the concurrent biochemical transformations that render the viral material competent for nuclear entry. We discuss both mathematical and biological consequences of our model, such as the formulation of an effective integrodifferential boundary condition embodying a memory kernel and optimal timing in maximizing viral probabilities.

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MS53

Kinetic Models for Polymer with Inertial Effects

Novel kinetic models for both Dumbbell-like and rigid-rod like polymers are derived, based on the probability distribution function $f(t, x, n, n')$ for a polymer molecule positioned at x to be oriented along direction n while embedded in a n' environment created by inertial effects. It is shown that the probability distribution function of the extended model, when converging, will lead to well accepted kinetic models when inertial effects are ignored such as the Doi models for rod like polymers, and the Finitely Extensible Non-linear Elastic (FENE) models for Dumbbell like polymers.

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MS53

Transport In Narrow Geometries Under Strong Confinement

Kinetic transport in thin plates or tubes, involving scattering of particles with a background, is modeled by subband type macroscopic equations for thedensity of particles. The result is a diffusion equation with the projection of the (asymptotically conserved) energy tensor on the confined direction(s) as an additional free variable, on large time scales. Classical transport of ions through protein channels and quantum transport of electrons in thin (SOI-type) semiconductor devices are discussed as examples of the application of this methodology. (Joint work with N. BenAbdallah and C. Heitzinger)

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MS54

On the Uniqueness of Weak Solutions to the 2D Euler Equations

An interesting class of initial data for solutions to the Euler equations in 2D are those for which uniqueness of solutions in the natural energy space exist, but for which the flow map can be highly irregular, indicating that perhaps such classes of initial data are near minimal for insuring uniqueness. I will discuss three such classes, two due to Yudovich and one to Vishik, and some properties of their flow maps.

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MS54

On Partial Regularity for Solutions of the Navier-Stokes System

A classical result of Caffarelli, Kohn, and Nirenberg states that the one dimensional Hausdorff measure of singularities of a suitable weak solution of the Navier-Stokes system is zero. We present a short proof of the partial regularity result which allows the force to belong to a singular Morrey space.

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MS54

Vanishing Viscosity Limits and Singular Perturbation Problems

We study the vanishing viscosity limit for certain Taylor-Couette flows in pipes and channels. We establish convergence of the Navier-Stokes solution to the corresponding Euler solution as viscosity vanishes in various norms. In the process we obtain a detailed analysis of the small-diffusion limit for a heat equation with drift, using a parametrix construction.

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MS54

Vortex Sheets in Domains with Boundary

Vortex sheets in 2D correspond to flows for which there is a discontinuity in the tangential component of velocity along a curve, while the normal component is continuous. In 1991 J.-M. Delort established the existence of a weak solution for the incompressible 2D Euler equations with vortex sheet initial data, under the hypothesis that the vorticity be of distinguished sign. Delort considered three flow contexts: full-space flow, flow on a two-dimensional compact manifold, and flow in a smooth, bounded domain. In this talk we will re-examine Delort's analysis for the case of bounded domain flows; while Delort considered the velocity formulation of the incompressible Euler equations we will discuss the vorticity formulation. We will discuss the possibility that mass of vorticity accumulates on the boundary of the domain and we study the dynamics of this vorticity defect. We extend Delort's analysis, as well as ours, to smooth, possibly unbounded, domains with boundary. We note that our results are consistent with the expected behavior of the vanishing visocity limit of the incompressible Navier-Stokes equations.

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MS55

Faber-Krahn Type Inequalities in Inverse Scattering Theory

We first consider the scattering of time harmonic plane waves by a perfectly conducting infinite cylinder of cross section D. We observe that the Dirichlet eigenvalues for the Laplacian in D can be determined from the far field pattern of the scattered wave and hence from the Faber-Krahn inequality we can obtain a lower bound for the area of D. We then consider the corresponding problem for a dielectric cylinder. Here we observe that a relatively new type of spectra called transmission eigenvalues can be determined from the far field pattern of the scattered wave and show that transmission eigenvalues exist and form a discrete set. We then obtain a Faber-Krahn type inequality for transmission eigenvalues which,if D is known, provide a lower bound on the index of refraction n(x). Of special interest is the case when cavities may be present,i.e. regions where n(x)=1.We consider both isotropic and anisotropic materials.

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MS55

Transformation Optics and Active Acoustic Cloaking Devices

In this talk, we shall describe our recent progress on the use of transformation optics to the design of active cloaking devices. The cloaking device makes the interior medium together with a source/sink in the cloaked region invisible to boundary/exterior wave detection. Finite energy solutions for these acoustic cloaking devices are studied in weighted Sobolev spaces with singular weights. We analyze the behavior of the finite energy solution in the cloaking medium, in the cloaked region, and at the interface between the two regions. A novel finite element discretization for the corresponding singular PDEs shall also be discussed.

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MS55

Inverse Obstacle Problems with Nonlinear Terms in the Underlying Equation

This talk will be concerned with determining hidden inclusions or obstacles from (Cauchy) data measurements on an accessible, external boundary. The underlying equation will be of second order elliptic type but may contain nonlinear terms in either the equation itself or the boundary condition. Further, these terms may themselves be unknown. The aim is to determine the minimal amount of data required in order to obtain uniqueness and to examine some reconstruction algorithms.

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MS55

On a Minimizing Problem in Conductivity Imaging from Interior Measurements

This talk concerns a non-smooth optimization problem occurring in conductivity imaging. The magnitude of the current density field while maintaining a prescribed voltage is assumed known. Local stability of the minimizer is shown to hold nearby an admissible interior data.

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MS56

Traveling Wave Solutions to Reaction-diffusion Systems

We will present some recent results on traveling waves in nonlinear reaction-diffusion equations and systems. We will pay particular attention to the generalized Fisher equation, which has applications in biology and chemistry.

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MS56

Coupled Chemotaxis-Fluid Models

We consider coupled chemotaxis-fluid models aimed to describe swimming bacteria, which show bio-convective flow patterns on length scales much larger than the bacteria size. This behaviour can be modelled by a system consisting of the chemotaxis equations coupled with the viscous incompressible fluid equations through transport and external forcing. We give global-in-time existence results for weak potentials, for small initial concentration of the chemical and for nonlinear diffusion of the cells.

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MS56

Stationary Patterns in Prey-predator Models with Stage Structure

We look at a diffusive prey-predator model with stage structure for the predator, which is in the form of a reaction-diffusion system with the homogeneous Neumann boundary condition, with the presence of a cross-diffusion term. We show that stationary patterns, i.e., nonconstant positive stationary solutions, emerge for this system as a

result of the presence of cross diffusion.

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MS56

Traveling Fronts to Auto-Catalytic System with Two Orders of Reactions

In this talk, we study the existence and non-existence of travelling wave to parabolic system of the form

$$a_t = a_{xx} - af(b); \quad b_t = Db_{xx} + af(b),$$

with f a degenerate nonlinearity. Using a complete new approach, we are able to derive sharp bounds on the minimum speed with interesting dependance relation on D, when $f(b) = b^m + kb^n$, where m, n are two different positive exponents and k a positive constant.

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MS57

Control and Stabilization of the Multilayer Rao-Nakra Beam System

We consider the multi-layer Rao-Nakra beam system with combinations of passive internal damping and active boundary damping. With passive internal damping alone, we can prove that the system is exponentially stable except in two exceptional cases: when all the wave speeds are the same, or when all wave speeds except one are the same and the common wave speeds match one of a sequence of critical numbers. In either case, a single feedback on one layer is sufficient to achieve exponential stability. Under some restrictions on parameters, we also show that boundary feedback alone is sufficient for exponential stability.

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MS57

Swimming Models and Their Controllability

We consider a simplified model of an abstract object, formed by narrow interconnected rectangles, which propels itself in a fishlike fashion in a fluid. The results include an asymptotic formula for “small” motions of this obect which is then applied to the study of its global controllability properties.

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MS57

Asymptotic and Spectral Properties of Double-walled Carbon Nanotube Model

We present the results on rigorous mathematical analysis of a model of a double-walled carbon nanotube (CNT). As is well-known, nanoscience is an extremely fast-developing area with numerous experimental and numerical results. CNT are elongated tubes with diameters in nanometer range and lengths in micron range. Double-walled CNTs are two concentrically nested CNTs with different characteristics. The individual tubes are not bonded together; they only interact through non-bonded Van-der-Waals forces. They remain free to slide and rotate independently with small resistive forces. It seems natural that the system of a nanometer size should be described as a quantum system and studied by using an appropriate Schrodinger operator. In fact, this method is the core of molecular simulations. However, at present quantum-mechanical methods have been used for analysis of single-walled CNT and no attempts have been made to deal with double-walled CNT. In our research, we use an alternative approach based on traditional continuum mechanics models such as beams, shells, and membranes. So, CNT are viewed as a continuous vibrating structures and modeled by PDEs. The main object of our analysis is a mathematical model of a double-walled CNT. We consider a system of two beams interacting through distributed Van-der-Waals forces. There are the most used beam models: Euler-Bernoulli beam and Timoshenko beam models. The second model is more complete since it takes into account not only transverse displacement of a vibrating beam but also torsional angle between the originally parallel cross-sections. At the beginning, double-walled CNTs have been modeled by two coupled E/B beams, then by E/B and T-beams. However, an agreement between numerical data provided by mathematical model and experimental data was not satisfactory. The latest set of models is given by two T-beams coupled through distributed Van-der-Waals forces. It is precisely our model. The model is governed by a system of four hyperbolic PDEs. It is really complicated and probably for this reason the results available in the literature are all computational. Our goal is to give purely theoretical analysis. In particular, we obtained explicit asymptotic formulas for the vibrational frequencies. Here we would like to add the following. In macroscopic vibrating systems high frequency vibrations are heavily damped and their amplitudes decrease in time very rapidly. That is why high frequency modes are not of primary interest for engineers. But for nanostructures, high frequency modes are almost not damped. So, our asymptotic analysis of high frequency vibrations (in terahertz frequency range) could be very important.

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MS57

Uniform Null Controllability of a Parabolic Equation with Rapidly Oscillating Periodic Coefficients

We consider a parabolic equation with fast oscillating periodic coefficients, and an interior control in a bounded domain. First, we prove sharp convergence estimates depending explicitly on the initial data for the corresponding uncontrolled equation; these estimates are new in a bounded domain, and their proof relies on a judicious smoothing of the initial data. Then we use those estimates to prove that the original equation is uniformly null controllable, provided a carefully chosen extra vanishing interior control is added to that equation. This uniform null controllability result is the first in the multidimensional setting for parabolic equations with oscillating coefficients. Finally, we prove that the sequence of null controls converges to the optimal null control of the homogenized equation when the period tends to zero.

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MS57

Stabilization of Structure-Acoustics Interactions for a Reissner-Mindlin Plate by Localized Nonlinear Boundary Feedbacks

This work addresses a system comprised of a wave equation coupled with a Reissner-Mindlin plate. The acoustic damping is restricted to the flexible boundary and only a portion of the rigid wall; the plate is likewise damped on a segment of its boundary. The nonlinearities in both feedbacks may include sub- and super-linear growth at infinity. We establish stabilization estimates and energy decay rates for this model.

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MS58

NonLinear Possio Integral Equation and AeroElastic Flutter Limit Cycle Oscillation

With a zero thickness wing structure model (Goland) that is linear but aerodynamics that is nolinear- inviscid isentropic flow characterised by the Euler full potential equation with Kutta-Joukowsky conditions - we show that Flutter is an LCO. The speed is a Hopf Bifurcation point, determined by the linearised model and so is the period. The key relation of the pressure jump to the wing normal velocity is now given by a 2D nonlinear time domain extension of the linear Possio Integral equation. As for the disturbed flow itself, we show that it can be decomposed as the sum of two parts, one part that produces the lift determined by nonlinear Possio equation and does not depend on the value of the ratio of specific heats; and can be linearised; and the other part which produces no lift but may contain discontinuities but not across the wing and cannot be linearized.

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MS58

Fluid-stucture Interaction Between Blood Flow and Thick Arterial Walls

A new effective 3D axially symmetric nonlinear hyperbolic-parabolic model of fluid-structure interaction between an incompressible, viscous fluid and a 3D (thick) elastic or viscoelastic structure will be presented. The model was motivated by the study of blood in muscular arteries. The resulting model is a generalization to the thick structure case of an effective model obtained earlier by the speaker and the co-authors. The new effective model reveals some novel features of the coupled problem, not observed in the thin structure case. The derivation of the model and its novel features will be discussed. This is a joint work with Andro Mikelic of the University of Lyon1, and Giovanna Guidoboni of the University of Houston.

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MS58

Boundary Layers for the Primitive Equations

We present in this lecture some convergence results related to the Linearized Primitives Equations (LPEs) as the viscosities go to zero. The (full nonlinear) Primitives Equations read:

$$(PEs)\quad \begin{cases} \dfrac{\partial \widetilde{\mathbf{v}}}{\partial t} + (\widetilde{\mathbf{v}} \cdot \nabla)\widetilde{\mathbf{v}} + \widetilde{w}\dfrac{\partial \widetilde{\mathbf{v}}}{\partial z} + fk \times \widetilde{\mathbf{v}} + \dfrac{1}{\rho_0}\nabla \widetilde{p} - \mu_{\widetilde{\mathbf{v}}}\Delta \widetilde{\mathbf{v}} - \nu_{\widetilde{\mathbf{v}}}\dfrac{\partial^2 \widetilde{\mathbf{v}}}{\partial z^2} = \\ \dfrac{\partial \widetilde{p}}{\partial z} = -\widetilde{\rho} g, \\ \nabla \widetilde{\mathbf{v}} + \dfrac{\partial \widetilde{w}}{\partial z} = 0, \\ \dfrac{\partial \widetilde{T}}{\partial t} + (\widetilde{\mathbf{v}} \cdot \nabla)\widetilde{T} + \widetilde{w}\dfrac{\partial \widetilde{T}}{\partial z} - \mu_{\widetilde{T}}\Delta \widetilde{T} - \nu_{\widetilde{T}}\dfrac{\partial^2 \widetilde{T}}{\partial z^2} = Q_{\widetilde{T}}, \\ \widetilde{\rho} = \rho_0(1 - \alpha(\widetilde{T} - T_0)). \end{cases}$$

One of our aims, among others, is to give the limit solution associated with the Linearized system of (PEs) that we obtain by dropping the nonlinear terms. However, a difficulty for the limit LPEs system (that is we set the viscosities to be equal to zero) lies in the fact that no set of *local* boundary conditions ensures its well-posedness. Several choices of *nonlocal* boundary conditions are possible. Hence, in view of the uniqueness, our aim is to give an asymptotic expansion of the solution of the LPEs at small viscosities confirming thus our choice for the boundary conditions.

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MS58

Limit Cycle Oscillations of Very Flexible High-Aspect-Ratio Wings

An aeroelastic analysis is performed for a flexible high-aspect-ratio wing representative of a high altitude long endurance (HALE) aircraft. A number of features relevant to the aeroelastic response of HALE aircraft are highlighted, including the sensitivity of the computed flutter boundary and limit cycle oscillations to aerodynamic data from computational fluid dynamics (CFD) simulations and wind tunnel tests, and the role of stall in the dynamic stability of high-aspect-ratio wings.

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MS58

Flutter Analysis of a Wedge Shaped Airfoil in Potential Flow

We study the effect of nonzero camber thickness on flut-

ter speed in potential flow using continuum models. We solve the Possio integral equation from which the Lift and Moment are computed. We examine specifically the cases M=0 and M=1 . Our main result is that the flutter speed increases with the thickness.

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MS59

Review of New Phase Field Models in Image Analysis and Microfluidics

I will review some recent results using phase field models in image analysis and microfluidics. The talk will include an overview of (a) Cahn-Hilliard methods for image inpainting, (b) a wavelet-Allen-Cahn method for image reconstruction, and (c) a diffuse interface model for the EWOD (electrowetting on dieletric) device.

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MS59

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 (e.g. materials science). 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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MS59

On Ionic Fluids in Ion Channels

We will study the dynamics of general ionic fluids, in particular those associated with ion channels. We will emphasize on the selectivities of ion channels as well as those related to the classical /Hodgkin//Huxley/ models.

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MS59

A Variational Approach to Bar Code Reconstruction

When a bar code is read by a reader, the reader produces a blurred noisy signal that lacks the original binary character. One method for recovering the code is minimization of the Rudin-Osher-Fatemi phase field functional, which involves a fidelity and total variation term. The binary structure of the original image allows for analytical results stating when this method will give back the original code. The method also allows for generalizations to two dimensions.

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MS60

Minimizers of the Lawrence-Doniach Functional in Parallel Applied Fields

We consider minimizers of the Lawrence-Doniach functional, which models highly anisotropic superconductors with layered structure, in the simultaneous limit as the layer thickness tends to zero and the Ginzburg-Landau parameter tends to infinity. In particular, we consider the properties of minimizers when the system is subjected to an external magnetic field applied either tangentially or normally to the superconducting planes. For normally applied fields, our results show that the resulting "pancake' vortices will be vertically aligned. In horizontal fields we show that there are two parameter regimes in which minimizers exhibit very different characteristics. The low-field regime resembles the Ginzburg-Landau model, while the high-field limit gives a "transparent state' described in the physical literature.

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MS60

Ginzburg-Landau-type Vortices in a Model for Liquid

Abstract not available at time of publication.

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MS60

Existence Results for Liquid Crystal Energies

We examine the problem of minimizing the Chen-Lubensky liquid crystal energy. In the case that the energy has a SmC ground state we show that anchoring conditions on the smectic layering at the boundary are needed in order for minimumizers to exist. We further give examples of strong and weak anchoring conditions that suffice.

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MS60

Disc Droplets, Ring Droplets, and Oval Droplets in Some Morphogenesis and Morphology Problems

The Gierer-Meinhardt system for morphogenesis in development and the Ohta-Kawasaki theory for block copolymer morphology give rise to one nonlocal geometric problem of finding a (often disconnected) subset of a given domain. The subset satisfies an equation that involves the curvature of the boundary of the subset and the inverse Laplacian of the characteristic function of the subset. Three solutions are found: a subset of many small discs, a subset of many small rings, and a small oval shaped subset. A resonance diagram determines the existence and stability of the first two solutions. It reveals a complicated landscape of the free energy functional. An analysis near a resonance point yields the third solution with unexpected properties.

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MS61

Dynamical Problems of Nonlinear (Visco) Elasticity

The dynamical equations of (standard models of) nonlinear elasticity form quasilinear hyperbolic systems, which are subject to shocks. The introduction of a strong dissipative mechanism converts these equations to quasilinear parabolic-hyperbolic systems (for strain-rate viscoelasticity). This lecture describes the subtle and critical roles of such dissipative mechanisms and corresponding invariance requirements for the global existence of solutions, for blowup of solutions, for time-periodic solutions, and for the construction of accurate numerical shock-capturing schemes.

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MS61

On the Necessary Conditions for Stability in Nonlinear Elasticity

Elastic equilibrium in solids capable of phase transformations can be modeled as a strong local minimizer of the energy functional. The necessary conditions for such local minimizers are well-known but poorly understood. I will discuss these conditions and their relative strengths. Many simple-sounding problems still remain open.

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MS61

Existence via the Inverse Formulation in 2-d Nonlinear Elasticity

Abstract not available at time of publication.

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MS61

On the Symmetry of Energy Minimising Deformations in Nonlinear Elasticity

Consider a homogeneous, isotropic, hyperelastic body that occupies a three-dimensional, thick spherical shell in its reference state and is subject to radially symmetric displacement boundary conditions on its inner or outer boundary. We show that for a large class of polyconvex stored-energy functions the radial minimiser of this problem is an absolute minimiser of the elastic energy. The key ingredient is a new radial-symmetrisation procedure that yields a one-to-one map. Such a one-to-one symmetrisation is important in Continuum Mechanics where interpenetration of matter must be prohibited.

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MS62

Nonlinear Subelliptic Equations

In this paper, we study the higher order regularity for weak solutions of a class of quasilinear subelliptic equations. We introduce the notion of ν-closed system vector fields, which includes all the previously studied nilpotent systems and extends them to some non-nilpotent systems of vector fields, including those generating the Lie Algebra of the rotation group $SO(n)$ and other non-compact semisimple and solvable Lie groups.

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MS62

Estimates of Hausdoff Measure of Free Boundaries

Here we will talk about estimates of the measure of the free boundary problems for equations the could be nonhomogeneous p-laplacian problems. The strong nondegeneracy of the solution is the technical contribution for this problems.

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MS62

The Structure of the Free Boundary for Lower Dimensional Obstacle Problems

Abstract not available at tinme of publication.

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MS62

A Bifurcation Phenomenon in Two-Phase Free Boundary Problems

In an ellipitc free boundary problem, the uniqueness of a viscosity solution of the boundary value-problem and of a minimizer of the variational problem in general fails. In the counter-examples we constructed, a bifurcation phenomenon presents. A critical situation exists so that the uniqueness problem has different answers to the different sides of the critical situation. The corresponding evalutionary problem explains this phenomenon.

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MS63

Existence of a Solution to a Three-Dimensional Axially Symmetric Moving-Boundary Biot Problem Arising in Modeling Blood Flow: the Womersly Flow

We study the existence of a solution to a three-dimensional axially symmetric, moving boundary problem arising in modeling blood flow. The model equations form a hyperbolic-parabolic system of partial differential equations of Biot type with degenerate diffusion. Degenerate diffusion is a consequence of the fact that the effects of the fluid viscosity in the axial direction of a long and slender tube are small in comparison with the effects of the fluid viscosity in the radial direction. Degenerate fluid diffusion and the hyperbolic features of the problem cause lower regularity of a weak solution and are a source of the main difficulties associated with the existence proof. Crucial for the existence proof is the viscoelasticity of vessel walls which provides the main smoothing mechanisms in the energy estimates. Using the Implicit Function Theorem we obtain existence of a solution which is a perturbation of the famous Womersley flow in a tube with fixed walls and periodic forcing, thereby providing the existence of a solution which is physiologically relevant. This result contrasts other related results in this field which primarily deal with small perturbations of solutions corresponding to the zero-velocity scenarios. Our estimates show that the viscoelasticity of vessel walls is crucial in smoothing out the sharp fronts which are generated by the heart' steep pressure pulse in human large-to-medium arteries. Numerical solution of the resulting nonlinear problem shows excellent agreement with experimental data.

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MS63

A Variational Approach to Nonlinear Elasticity of Non-Euclidean Plates.

This talk is motivated by studying elasticity of thin structures which show non-zero strain at free equilibria (*non-Euclidean plates*). Many growing tissues (leaves, flowers or marine invertebrates) exhibit complicated configurations during their free growth and one would like to have them reproduced with man-made means. Recall that a smooth Riemannian metric on a simply connected domain can be realized as the pull-back metric of an orientation preserving deformation if and only if the associated Riemann curvature tensor vanishes identically. When this condition fails, one seeks a deformation yielding the closest metric realization. We set up a variational formulation of this problem by introducing the non-Euclidean version of the standard nonlinear elasticity energy functional, and establish its Γ-limit under a proper scaling. As a corollary, we obtain new

necessary and sufficient conditions for existence of a $W^{2,2}$ *isometric immmersion* of a given 2d metric, into $\mathbf{R}^3$.

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MS63

Cauchy Problem for Relativistic Landau-Maxwell System

We prove the global existence of classical solutions for the relativistic Landau-Maxwell system near the global Maxwellian with generic initial data. This is a joint work with Hongjun Yu.

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MS64

A Kinetic Model for the Sedimentation of Rod-like Particles

The sedimentation of suspensions of rod-like particles shows an interesting pattern formation that has been studied by several authors in theoretical, numerical and experimental work. Here we try to understand these phenomena by considering a kinetic model which couples a microscopic Smoluchowski equation (for the rod orientation) to the macroscopic Stokes equation. By looking at special flow configurations and scalings, we derive simpler models which describe concentration. We show results of numerical simulations and present algorithms for a detailed simulation of the microscopic equation.

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MS64

Kinetic Theory and Lax equations for shock clustering

We derive kinetic equations that describe the clustering of shocks in scalar conservation laws with random initial data. These equations have the structure of a Lax pair, and admit remarkable exact solutions for Burgers equations. There are strong hints that the kinetic equations form a 2+1-dimensional completely integrable system.

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MS64

Instability and Mixing in Driven and Active Complex Fluids

Complex fluids are fluids whose suspended microstructure feeds back and influences the macroscopic flow. A well-known example is a polymer suspension and a novel one is a bacterial bath wherein many swimming micro-organisms interact with each other through the surrounding fluid. In either case, these systems can display very rich dynamics even at system sizes where inertia is negligible, and both systems have important applications to micro-fluidic mixing and transport. I will discuss examples of each where hydrodynamic instabilities drive these systems into dynamics characterized by the emergence of coherent structures, multiple time-scales, and strong fluid mixing.

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MS64

Kinetic Models for Dilute Suspensions and Shear Bands in Viscoelastic Flows

In this talk we will present a class of models introduced by Doi and describing suspensions of rod–like molecules in a solvent fluid. Such kinetic models couple a microscopic to a macroscopic equation. The macroscopic one is the Stokes equation for the fluid velocity, the microscopic equation is a Fokker–Planck (Smoluchowski) equation for the probability distribution of rod orientations in every point of physical space. For certain parameter values, the velocity gradient vs. stress relation defined by the stationary and homogeneous flow is not rank–one monotone. This induces that steady states can have discontinuous solutions analogous to the ones studied in the context for macroscopic viscoelastic models (e.g. for Oldroyd-B models) and spurt phenomena or shear bands in that context. (joint work with Ch. Helzel, Univ. of Bochum and F. Otto, Univ. of Bonn)

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MS65

An Example of Global Classical Solution for the Perona-Malik Equation

The Perona–Malik equation

$$u_t = \mathrm{div}\left(\varphi'(|\nabla \mathrm{u}|)\frac{\nabla \mathrm{u}}{|\nabla \mathrm{u}|}\right)$$

is a typical example of forward-backward diffusion process. It is well known that in dimension $n = 1$ the Cauchy problem does not admit global-in-time classical solutions (namely $C^{2,1}$ or even C^1 solutions) if the initial condition

u_0 is transcritical, namely $|\nabla u_0(x)| - 1$ is a sign changing funcion. On the contrary, we show that in dimension $n \geq 2$ there are examples of global-in-time solutions of class $C^{2,1}$ with transcritical initial datum.

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MS65

Anistropic Diffusion Models Old and New

Since the pioneering work of Perona and Malik, so-called anisotropic diffusion has found a fertile ground of application in Image processing. A survey of models will be given with particular emphasis on second and fourth order diffusions and their application to the resolution of important basic image processing tasks. Analytical results will be complemented with substantiating numerical experiments.

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MS65

A Semidiscrete Scheme for the Perona-Malik Equation

I present a semidiscrete scheme for the Perona-Malik Equation in one space dimensione, rigorously proving the convergence for a special class of initial data. Particular emphasis will be given to the different behavior of the solutions in the different time-scales, and the long-time behavior will be discussed in detail.

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MS66

The Free Boundary Value Problem of the Navier-Stokes Equations with Surface Tension

We study the free boundary value problem of the Navier Stokes equations on a moving domain of finite depth, bounded above by a free surface and bounded below by a solid flat domain. We show that there exists a unique, global-in-time solution for small initial data in energy spaces.

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MS66

Statistical solutions for the 2D Euler equation

In the study of Euler and Navier-Stokes equations we can consider two different approaches. The most classical one consist in the study of the equations with specifique initial and boundary conditions. Another approach, the so-called statistical approach, consist in the construction of suitable probability measures and study its evolution in time according to the corresponding dynamic. The framework of stochastic analysis can be used to construct solutions. In our presentation, we follow the second point of view to present some results on the 2D Euler equation with periodic boundary conditions. We construct surface type measures on the level sets of the renormalized energy and establish the existence of weak solutions living on such level sets. We also prove the existence of weak solutions for the forward and backward transport equations associated with the 2D Euler equation. Such solutions can be interpreted, respectively, as a statistical Lagrangean and statistical Eulerian description of the motion of the fluid.

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MS66

Existence for the 2D Vortex-wave System

The 2D vortex-wave system is obtained by coupling the 2D vorticity equation with the equation for the evolution of point vortices. Our objective in this talk is to present recent results for this system, including existence of a weak solution with initial vorticity in L^p, $p > 2$.

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MS66

A Generalization of the Helmholtz-Kirchhoff Model.

The two-dimensional Navier-Stokes equations are rewritten as a system of coupled nonlinear ordinary differential equations. These equations describe the evolution of the moments of an expansion of the vorticity with respect to Hermite functions and of the centers of vorticity concentrations. We prove the convergence of this expansion and show that in the zero viscosity and zero core size limit we formally recover the Helmholtz-Kirchhoff model for the evolution of point-vortices. The present expansion systematically incorporates the effects of both viscosity and finite vortex core size. This is joint work with Ray Nagem, Guido Sandri and David Uminsky of Boston University.

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MS67

Sensitivity Analysis in Imaging

An imaging procedure is an inverse problem. While generally ill-posed, such problems are solvable on an adequate subspace. In particular, the small perturbation case can be rigorously studied. Considering the scalar Helmholtz equation and the elasticity model, we perform asymptotic analysis of the perturbed fields when a small inclusion is added in an homogeneous background. Using this perturbation analysis we derive imaging algorithms and discuss their resolution limits.

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MS67
Imaging by Cross Correlation of Noisy Signals

We introduce a self-consistent theoretical framework for the analysis of interferometric imaging techniques. We describe the conditions required to observe the emergence of the Green's function between two sensors from the cross correlation of ambient noise recorded by the sensors. We discuss passive sensor imaging by migration of the cross correlations. We show that reflectors can be imaged in a scattering medium with passive sensor networks by migrating suitable fourth-order cross correlations.

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MS67
Array Imaging of Sparse Scenes with L1 Minimization

Most array imaging is done with variants of an L2 minimization algorithm, including travel time migration which is a simplified form of it for wide area imaging. With the exception of SVD-based algorithms, L2 minimization is not efficient for sparse image scenes. We will describe an L1 based imaging algorithm that works well when there is sparsity, analyze it using ideas from compressed sensing, and show results of numerical simulations (work jointly with A. Chai).

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MS67
Data Filtering for Coherent Array Imaging in Heavy Clutter

We consider the problem of imaging small reflectors embedded in heavy cluttered media. To make coherent imaging possible in such media we propose to filter the unwanted echoes due to the cluttered medium prior to imaging. The main idea is to identify windows in the time-direction of arrival plane that contain the coherent echoes from the reflectors, by doing a spectral decomposition of the local cosine transform of the response matrix recorded at the array.

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MS68
Power-law Variational Principles and Aronsson Equations

Γ-convergence results for power-law functionals acting on fields which satisfy constant rank differential constraints will be presented, together with a discussion of selected Aronsson equations associated to minimization problems for the limiting supremal functionals.

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MS68
Stability Analysis of Generalized Forchheimer Flows in Porous Media.

This presentation focuses on the stability of non-linear flows of slightly compressible fluids in porous media not adequately described by Darcy's law. We study a class of generalized nonlinear momentum equations which covers three well-known Forchheimer equations, the so-called two-term, power, and three-term laws. The generalized Forchheimer equation is inverted to a non-linear Darcy equation with implicit permeability tensor depending on the pressure gradient. This results in a degenerate parabolic equation for the pressure. Two classes of boundary conditions are considered, given pressure and given total flux. The uniqueness, Lyapunov and asymptotic stability of the solutions, and their continuous dependence on the boundary data are analyzed.

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MS68

Asymptotic Analysis of Phase Field Formulations of Bending Elasticity Models

In this talk, we give the asymptotic analysis of sharp interface analysis of the phase field function in some phase field models for Willmores problem or equilibrium lipid bilayer cell membrane problems. We derive the explicit expression of the asymptotic expansion of the phase field functions minimizing the Willmore energy. Based on the structure of the phase field functions obtained via the asymptotic analysis, we can then demonstrate the consistency of phase field models and the sharp interface models. Also some error estimates of energy and Euler number formulae are further analyzed. Some numerical experiments are performed to verify our assumptions and results. The results of this paper lead to better understanding of the structure of the phase field functions in the phase field models for Willmores problem and the equilibriums configurations of the lipid vesicle membranes.

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MS69

Superconductivity Near the Normal State in the presence of current

We consider the linearization of the time-dependent Ginzburg-Landau near the normal state. We assume that an electric current is applied through the sample, which captures the whole plane, inducing thereby, a magnetic field. We show that independently of the current, the normal state is always stable. Using Fourier analysis the detailed behaviour of solutions is obtained as well. Relying on semi-group theory we then obtain the spectral properties of the steady-state elliptic operator. We shal also consider the spectral properties of the same elliptic operator near a flat wall, and obtain the critical current in the limit of small and large normal conductivity

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MS69

Gauge Uniqueness of Solutions to the Ginzburg-Landau System for Small Bi-dimensional Domains

We study the problem of type I behavior and gauge uniqueness of solutions to the two-dimensional Ginzburg-Landau system, in the presence of an applied field when the sample is sufficiently small. We show that there are only two possible solutions: one normal and one vortex-free, with the normal solution being the only solution above a critical field and the vortex-free being the global minimizer below.

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MS69

Ginzburg-Landau Vortices Driven by the Landau-Lifschitz-Gilbert Equations

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 Schrödinger equation and a gradient flow. We study the motion of the vortex centers under this evolution equation.

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MS69

Time-dependent Ginzburg-Landau with an Applied Voltage

We study a Ginzburg-Landau model for the response of a thin superconducting wire to an applied voltage difference. In this model, the voltage difference leads to time-periodic boundary conditions. Different asymptotic regimes will be discussed including large/small voltage, and long/short wires. Physically and numerically observed phenomena include period doubling, chaotic behavior and boundary layer effects.

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MS70

Diffusion Generated Motion for Evolving Interfaces in Imaging and Vision

We describe efficient and accurate algorithms for generating a variety of interfacial motions of interest in image processing and computer vision. They reduce geometric motions to essentially two simple operations: Redistancing and convolution with a kernel, both of which have fast, classical algorithms. Our methods can be seen as a variant of Merriman, Bence, and Osher's threshold dynamics which itself stems from operator splitting on well-known phase field formulations of certain geometric motions.

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MS70

On the Convergence of the Ohta-Kawasaki Equation to Motion by Nonlocal Mullins-Sekerka Law

We rigorously justify the nonlocal Mullins-Sekerka dynamics from the Ohta-Kawasaki equation on any smooth domain in space dimensions $N \leq 3$. These equations arise in modeling microphase separation in diblock copolymers. We establish convergence results for the case of well-preparedness of the initial data and smoothness of the limiting interface. Our method makes use of the "Gamma-convergence' of gradient flows scheme initiated by Sandier and Serfaty and the constancy of multiplicity of the limiting interface due to its smoothness. For the case of radially symmetric initial data without well-preparedness, we give a new and short proof of Henry's result for all space dimensions. Finally, we establish transport estimates for solutions of the Ohta-Kawasaki equation characterizing their transport mechanism

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MS70

Smoke-rings and Toroidal Tubes in Some Activator-inhibitor

Ring shaped objects in space have been observed in many physical and biological systems. We find them in the Gierer-Meinhardt system for morphogenesis in cell development. This system is a minimal model that provides a theoretical bridge between observations on the one hand and the deduction of the underlying molecular-genetic mechanisms on the other hand. In the non-saturation case we show the existence of a smoke-ring type solution in space. The activator component of the solution vanishes outside the smoke-ring and remain large on the smoke ring. In the saturation case the GM system is reduced to a nonlocal geometric problem where a solution is a set in space that satisfies an equation that links the mean curvature of the boundary of the set to the Newtonian potential of the set. A torus shaped, tube like solution is found.

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MS70

Statistical Analysis of Shapes based on Nonlinear Elasticity and Phase Field represented Geometries

The talk deals with the covariance analysis of a set of of given shapes. These shapes are interpreted as boundary contours of elastic objects and algorithmically treated as phase fields. Based on the notion of nonlinear elastic deformations from one shape to another, a suitable linearization of geometric shape variations is introduced. Once such a linearization is available, a principal component analysis can be investigated. This requires the definition of a covariance metric—an inner product on linearized shape variations. The resulting covariance operator robustly captures strongly nonlinear geometric variations in a physically meaningful way and allows to extract the dominant modes of shape variation. The underlying elasticity concept represents an alternative to Riemannian shape statistics. In this paper we compare a standard L^2-type covariance metric with a metric based on the Hessian of the nonlinear elastic energy. Furthermore, we explore the dependence of the principal component analysis on the type of the underlying nonlinear elasticity. For the built-in pairwise elastic registration, a relaxed model formulation is employed which allows for a non-exact matching. Shape contours are approximated by single well phase fields, which enables an extension of the method to a covariance analysis of image morphologies. The model is implemented with multilinear finite elements embedded in a multi-scale approach. The characteristics of the approach are demonstrated on a number of illustrative and real world examples in 2D and 3D. The talk is based on joint work with Benedikt Wirth.

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MS71

Weak Solutions in Second-gradient Nonlinear Elasticity

We consider a class of second-gradient elasticity models for which the internal potential energy is the sum of a convex function of the second gradient of the deformation and a general function of the first gradient. In consonance with classical nonlinear elasticity, the latter is assumed to grow unboundedly as the determinant of the gradient approaches zero. While the existence of a minimizer is routine, the existence of weak solutions is not. We focus on that question here. We provide a general setting in which the determinant of any admissible deformation corresponding to bounded energy is strictly positive on the closure of the domain. In particular, the total potential energy is readily shown to be Gateaux differentiable at an energy minimizer. We obtain weak solutions for a wide variety of mixed boundary conditions on Lipshitz domains.

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MS71

n-Harmonic Deformations of Annuli, The Art of Integration Of Free Lgrangians

We study homeomorphisms $h : X \longrightarrow Y$ between annuli in R^n. The aim is to minimize the associated n-harmonic

energy integral. Because of conformal invariance such an alternative to the classical Dirichlet energy has drawn the attention of researchers in n-dimensional Geometric Function Theory. We adopt the interpretations and ideas of nonlinear elasticity where the applied aspects of our results originated. The underlying integration of nonlinear differential forms, called free Lagrangians, comes into play.

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MS71

Violation of the Complementing Condition and Local Bifurcation in Nonlinear Elasticity

In this talk we review several examples of boundary value problems in nonlinear elasticity where the linearization about a suitable trivial solution (depending on a parameter) fails to satisfy the complementing condition (CC). The CC is an algebraic compatibility requirement between the principal part of a linear elliptic differential operator and the principal part of the corresponding boundary operators. The examples we review suggest that failure of the CC implies the existence of bifurcating branches of solutions accumulating at the point where the CC fails. We will discuss the essential features of this relationship in a more general context.

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MS71

A Degree Theory for Proper Fredholm Maps in Continuum Mechanics

We present a topological degree theory for proper Fredholm maps that applies to the equilibrium equations of nonlinear continuum mechanics. The equations are of quasilinear elliptic type in a bounded domain subject to displacement/traction boundary conditions. Applications are made directly to some compressible and incompressible elasticity and steady state Navier-Stokes equations with global continuation and existence results.

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MS72

Self-similar Solutions and Long-time Asymptotics for Fully Nonlinear Parabolic Equations

I will present results on the existence and uniqueness of a self-similar solution of a fully nonlinear, parabolic equation (an example of which include the Bellman-Isaacs equation arising in the theory of stochastic optimal control and stochastic differential game theory). As an application, we are able to describe the long-time behavior of solutions to the Cauchy problem, and derive a conservation law which generalizes the conservation of mass in the case of the heat equation. The scaling invariance property of the self-similar solution depends on the nonlinear operator, and is in general different from that of the heat kernel. We will see that this difference has an interesting interpretation in terms of controlled diffusion processes. This work is joint with M. Trokhimtchouk.

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MS72

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MS72

Asymptotic Energy Concentration in the Phase Space of the Weak Solutions to the Navier-Stokes Equations

We consider the asymptotic behavior of the weak solution to the Navier-Stokes equations in whole space $\mathbf{R}^n$. More precisely, we consider the asymptotic behavior of the lower frequency part of solutions to the Navier-Stokes equations. In fact, the kinetic energy of the lower frequency part of solutions dominates the total energy of the solution asymptotically, if the initial values have some lower frequency. We characterize the set of initial data which causes the energy concentration to the lower frequency part of the solution.

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MS72

Montonocity Formulas for Free Boundary Problems on Manifolds.

For free boundary problems on Euclidean spaces, the monotonicity formulas of Alt-Caffarelli-Friedman and Caffarelli-Jerison-Kenig are cornerstones for the regularity theory. I will present the analogs of these results for the Laplace-Beltrami operator on Riemannian manifolds. As an application I will show that the new monotonicity theorems can be employed to prove the Lipschitz continuity for the solutions of a general class of two-phase free boundary problems. This is a joint work with E. Teixeira.

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MS73

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MS73

Rarefaction Wave Interaction for the Unsteady Transonic Disturbance Equations

We study a Riemann problem for the unsteady transonic small disturbance equations that results in a diverging rarefaction problem. The self-similar reduction leads to a boundary value problem with equations that change type (hyperbolic-elliptic) and a sonic line that is a free boundary. We summarize the principal ideas and present the main features of the problem. The flow in the hyperbolic part can be described as a solution of a degenerate Goursat boundary problem, the interaction of the rarefaction wave with the subsonic region is illustrated and the subsonic flow is shown to satisfy a second order degenerate elliptic boundary problem with mixed boundary conditions.

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MS73

A Two-phase Stefan Problem for the Unsteady Transonic Small Dis- turbance Equations

A complex structure is found in numerical solutions of weak shock reflection problems for the unsteady transonic small disturbance equa- tions, the nonlinear wave system, and the full Euler equations at a set of parameter values for which regular reflection is impossible. The solutions contain a sequence of triple points and tiny supersonic patches embedded in the subsonic flow directly behind a leading triple point. The supersonic patches are separated from the subsonic flow by a sonic line of complex shape that contains embedded shock waves. This sonic line can be considered a free boundary, and the resulting free boundary problem for a system of equations of mixed type results in a new type of problem that has not previously been formulated or analyzed. As a step in this direction, we pose a much simpler problem for the unsteady transonic small disturbance equations that con- tains some of the same features: a free boundary consisting of a sonic line containing an embedded shock, and transonic coupling between the subsonic and supersonic regions. We linearize the problem and solve it exactly. We also obtain numerical solutions of the nonlinear problem.

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MS73

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MS74

Variational Characterization of Solutions of Nonlinear Parabolic Equations

This talk will describe some variational characterizations of the solutions of initial boundary value problems for parabolic equations and systems of parabolic type. These characterizations enable some different proofs of existence uniqueness and other results for these equations.

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MS74

Smoothing Properties and Lack of Compactness for a Coupled Fluid-Structure Semigroup

In this talk we shall derive certain qualitative properties for a partial differential equation (PDE) system which comprises (parabolic) Stokes fluid flow and a (hyperbolic) elastic structure equation. The appearance of such coupled PDE models in the literature is well-established, inasmuch as they mathematically govern many physical phenomena; e.g., the immersion of an elastic structure within a fluid. The coupling between the distinct hyperbolic and parabolic dynamics 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. However, one problem with this fluid-structure semigroup setup is that, due to the definition of the domain of the generator, there is no immediate implication of smoothing in all the fluid-structure variables; viz., the resolvent of the generator is *not* compact on the finite energy space. Consequently, one is presented with the basic question of whether smooth initial data will give rise to higher regularity of the solutions. Accordingly, one main result described here states that the mechanical, fluid, and pressure variables do in fact enjoy a greater regularity if an extra unit of Sobolev smoothness is imposed upon the initial structural component (only). A second problem of the model is the inherent lack of long time stability. In this connection, a second result described here provides for uniform stabilization of the fluid-structure dynamics, by means of the insertion of a damping term at the interface between the two media.

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MS74

Stability of Inverse Problems for The Wave Equation

Consider the inverse problem of determining the coefficients from the Dirichlet to Neumann map on the boundary for the wave equation with known initial conditions. In this talk, the speaker will discuss some recent stability study of the nonlinear inverse problem and the implications on inverse scattering problems. Recent results on related inverse problems will also be highlighted.

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MS74

Uniform Stabilization of the System of Dynamic Elasticity with Nonlinear Dissipation in the Dirichlet Boundary Conditions

We consider the system of dynamic elasticity defined on a bounded domain, with a nonlinear, nonlocal, dissipative term in the Dirichlet boundary conditions; and we establish its uniform stability in the space $L^2 \times H^{-1}$ of optimal regularity. Two approaches will be noted: one is a direct approach; the other is instead based on the very strong property that B^*L for the linear model is bounded, L^2 on the boundary in time and space. In both cases, a pseudodifferential analysis is needed. This is joint work with I. Lasiecka. It is a companion version of similar results originally established by the authors for wave equations with nonlinear, nonlocal dissipative terms in the Dirichlet boundary conditions.

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MS74

Stabilty of Moving Structures

The stability of moving wings and moving structures is an open problem. Several destructions of unmanned flying objects occur during the shape dynamical changes. Indeed, in this period, no classical eigenmodes analysis is available. We extend the stability criteria introduced in *Optimal Morphing Control* (by A.V. Balakrishnan and J.-P. Zolesio, in Sixth International Conference on Mathematical Problems in Engineering and Aerospace Sciences, Cambridge, 2007), and present new results concerning moving boundaries with Neumann boundary condition (including some sharp regularity and tube's derivative).

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MS75

The Dirichlet Problem for the Relativistic Heat Equation

To correct the infinite speed of propagation of the classical linear diffusion equation Ph. Rosenau proposed the tempered diffusion equation

$$\frac{\partial u}{\partial t} = \nu \operatorname{div}\left(\frac{|u|Du}{\sqrt{u^2 + \frac{\nu^2}{c^2}|Du|^2}}\right), \tag{3}$$

where ν is a constant representing a kinematic viscosity and c the speed of light. This equation was derived by Y. Brenier by means of Monge-Kantorovich's mass transport theory and he named it as the relativistic heat equation. In

a a series of papers we have studied existence and uniqueness of entropy solutions for the Cauchy problem and for the homogeneous Neumann problem associated to a class of quasi-linear parabolic equations which include as a particular case the relativistic heat equation. Here we are interested in the Dirichlet problem associated to the relativistic heat equation,

$$\begin{cases} \dfrac{\partial u}{\partial t} = \nu \operatorname{div}\left(\dfrac{uDu}{\sqrt{u^2 + \frac{\nu^2}{c^2}|Du|^2}}\right) & \text{in } Q_T = (0,T) \times \Omega \\ u = g & \text{on } S_T = (0,T) \times \partial\Omega, \\ u(0,x) = u_0(x) & \text{in } \Omega \end{cases} \tag{4}$$

where Ω is an open bounded subset of R^N with Lipschitz boundary $\partial\Omega$, $0 \leq u_0 \in L^\infty(\Omega)$ and $0 \leq g \in L^\infty(\partial\Omega)$. We prove existence and uniqueness of entropy solutions for the Dirichlet problem. This problem is however more delicate than the Cauchy problem in R^N or the homogeneous Neumann one. In particular, difficulties arise because of the fact that the boundary condition is in general not attained and this condition has to be weakened to become an obstacle condition on the boundary.

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MS75

Afem for Shape Optimization Problems

We examine shape optimization problems in the context of inexact sequential quadratic programming. Inexactness is a consequence of using adaptive finite element methods (AFEM) to approximate the state equation, update the boundary, and compute the geometric functional. Numerical simulations illustrating the method are presented for the design of a drag minimizing object and a cantilever minimizing compliance.

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MS75

Shape Optimization of Peristaltic Pumping

We present a variational method for optimizing peristaltic pumping in a two dimensional periodic channel with moving walls to pump fluid (peristalsis is common in biology). No a priori assumption is made on the wall motion, except that the shape is static in a moving wave frame. Thus, we pose an infinite dimensional optimization problem and solve it with finite elements. L^2-type projections are used to compute quantities such as curvature and boundary stresses.

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MS76
Spurious Caustics of Dispersion Relation Preserving schemes

We presently determine classes of traveling solitary wave solutions for a differential approximation of a dispersion-relation preserving scheme by means of an hyperbolic ansatz. The occurance of such spurious solitary waves results in a non-vanishing numerical error for arbitrary time in unbounded numerical domains, leading to the structural instability of the scheme, since the space of solutions encompasses types of solutions (solitary waves) that are not solution of the original continuous equations.

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MS76
Traveling Wave Phenomena to the Modified Korteweg de Vries-Burgers Equation

In this talk, our goal is to study a modified Korteweg-de Vries-Burgers equation with two higher–order nonlinearities. An asymptotic analysis of traveling wave solutions is established by means of the qualitative theory of differential equations. An approximate solution with arbitrary velocity is obtained by using the decomposition method, which agrees well with the phase plane analysis.

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MS76
Regularity of Attractor for 3D Ginzburg-Landau equation

A three dimensional Ginzburg-Landau type equation with periodic initial value condition is considered. Firstly, the smoothing property of the solution is obtained by a uniform priori estimates; then, the existence of the global attractors, $_i \subset H_p^i(\Omega)$ $(i = 2, 3, \cdots)$, of the semi-group $\{S^{(i)}(t)\}_{t\geq 0}$ of operators generated by the equation is presented by using the compactness principle; finally, the regularity of the global attractors is proved by the decomposition of semi-group.

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MS76
Numerical Study of a Boussinesq System

We presently study the propagation, as well as the collision, of solitary waves. A Boussinesq system for two-way propagation of interfacial waves in a rigid lid configuration is derived. If, in most cases, the nonlinearity is quadratic, when the square of the depth ratio gets close to the density ratio, the coefficients of the quadratic nonlinearities become small and cubic nonlinearities must be considered.

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MS77
Imaging in Random Waveguides

I will present a new method for imaging sources in random waveguides, from the time traces of the signals recorded at remote arrays of passive sensors. By random waveguides we mean that the wave speed has rapid fluctuations, that cause wave scattering and a significant loss of coherence of the signals at the array. Our imaging method is based on a special form of transport equations in random waveguides, and it can determine in a statistically stable manner the location of sources in the waveguide and statistical information about the wave speed fluctuations.

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MS77
Active Exterior Cloaking

We present a new method for cloaking an object from a known incident wave. This method is based on active devices that create a region, outside but near the devices, with small wave amplitudes and while not significantly radiating waves. An object in this region is for all practical purposes invisible. We will discuss how this method relates to array imaging.

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MS77
Limit of Fluctuations of Solutions of the Wigner Equation for White-noise Potentials

Large distance wave energy propagation in random media can often be described by kinetic equations. I will describe some recent results on the correctors to that limit when the random potential is time-dependent. This is a joint work with T. Komorowski.

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MS77
Multi-Scale Approach to Seismic Inverse Scattering and Partial Reconstruction via Microdiffraction

Tomography

We present a framework for inverse scattering via imaging and partial reconstruction in connection with limited boundary acquisition geometry. We first discuss a microlocal analysis viewpoint using the generalized Radon transform. Then we introduce a construction using downward data continuation leading to the introduction of microdiffraction tomography. To carry out the analysis we make use of higher-dimensional curvelets (Joint research with H. Smith, G. Uhlmann, S. Wang and B. Ursin.)

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