<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Event</th>
<th>Speaker</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>September 05, 2014</td>
<td>3:00pm-4:00pm</td>
<td>Applied Interdisciplinary Mathematics</td>
<td>Di Liu (Michigan State University) A multiscale method for optical responses of nano structures</td>
<td>1084 East Hall</td>
</tr>
<tr>
<td>September 12, 2014</td>
<td>3:00pm-4:00pm</td>
<td>Applied Interdisciplinary Mathematics</td>
<td>Liliana Borcea (University of Michigan) Imaging with waves in complex environments</td>
<td>1084 East Hall</td>
</tr>
<tr>
<td>September 19, 2014</td>
<td>3:00pm-4:00pm</td>
<td>Applied Interdisciplinary Mathematics</td>
<td>Jianfeng Lu (Duke University) Transition path process and coarse-graining stochastic systems</td>
<td>1084 East Hall</td>
</tr>
<tr>
<td>September 26, 2014</td>
<td>3:00pm-4:00pm</td>
<td>Applied Interdisciplinary Mathematics</td>
<td>Robert Deegan (University of Michigan) Splashing</td>
<td>1084 East Hall</td>
</tr>
<tr>
<td>October 03, 2014</td>
<td>3:00pm-4:00pm</td>
<td>Applied Interdisciplinary Mathematics</td>
<td>Jeffrey Fessler (University of Michigan) Optimized first-order convex minimization methods</td>
<td>1084 East Hall</td>
</tr>
<tr>
<td>October 10, 2014</td>
<td>3:00pm-4:00pm</td>
<td>Applied Interdisciplinary Mathematics</td>
<td>Benjamin Schweinhart (Princeton University) Topological Similarity of Random Cell Complexes, and Applications</td>
<td>1084 East Hall</td>
</tr>
<tr>
<td>October 17, 2014</td>
<td>3:00pm-4:00pm</td>
<td>Applied Interdisciplinary Mathematics</td>
<td>Alberto Figueroa (University of Michigan) Towards predictive cardiovascular modeling: Simulation of short-term arterial adaptations in 3D subject-specific models</td>
<td>1084 East Hall</td>
</tr>
<tr>
<td>October 24, 2014</td>
<td>3:00pm-4:00pm</td>
<td>Applied Interdisciplinary Mathematics</td>
<td>Rustum Choksi (McGill University) Self-Assembly: Variational models, Energy Landscapes, and Metastability</td>
<td>1084 East Hall</td>
</tr>
<tr>
<td>October 31, 2014</td>
<td>3:00pm-4:00pm</td>
<td>Applied Interdisciplinary Mathematics</td>
<td>Dionisios Margetis (University of Maryland) A tale of three scales in crystal evolution</td>
<td>1084 East Hall</td>
</tr>
<tr>
<td>November 07, 2014</td>
<td>3:00pm-4:00pm</td>
<td>Applied Interdisciplinary Mathematics</td>
<td>Christiane Jablonowski (UM) Adaptive Mesh Refinement (AMR) and Variable-Resolution Techniques for Weather and Climate Models</td>
<td>1084 East Hall</td>
</tr>
<tr>
<td>Date</td>
<td>Time</td>
<td>Seminar</td>
<td>Speaker</td>
<td>Location</td>
</tr>
<tr>
<td>--------------------</td>
<td>------------</td>
<td>--------------------------</td>
<td>-------------------------------------------------------------------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>Friday, November 14, 2014</td>
<td>3:00pm-4:00pm</td>
<td>Applied Interdisciplinary Mathematics</td>
<td>Jarvis Haupt (University of Minnesota) Locating Outliers in Large Matrices with Adaptive Compressive Sampling</td>
<td>1084 East Hall</td>
</tr>
<tr>
<td>Friday, November 21, 2014</td>
<td>3:00pm-4:00pm</td>
<td>Applied Interdisciplinary Mathematics</td>
<td>Ken Elder (Oakland University) Multi-scale modeling from the top down</td>
<td>1084 East Hall</td>
</tr>
<tr>
<td>Friday, November 28, 2014</td>
<td>3:00pm-4:00pm</td>
<td>Applied Interdisciplinary Mathematics</td>
<td>Thanksgiving (None specified) Thanksgiving</td>
<td>1084 East Hall</td>
</tr>
<tr>
<td>Friday, December 05, 2014</td>
<td>3:00pm-4:00pm</td>
<td>Applied Interdisciplinary Mathematics</td>
<td>Laura Miller (University of North Carolina, Chapel Hill) The fluid dynamics of jellyfish swimming and feeding</td>
<td>1084 East Hall</td>
</tr>
<tr>
<td>Friday, January 09, 2015</td>
<td>3:00pm-4:00pm</td>
<td>Applied Interdisciplinary Mathematics</td>
<td>Noa Kraitzman (Michigan State University) Bifurcation and competitive evolution of network morphologies in the strong Functionalized Cahn-Hilliard equation</td>
<td>1084 East Hall</td>
</tr>
<tr>
<td>Friday, January 16, 2015</td>
<td>3:00pm-4:00pm</td>
<td>Applied Interdisciplinary Mathematics</td>
<td>Manuel Gnann (Fields Institute and the University of Michigan) The moving contact line in viscous thin films: a singular free boundary problem</td>
<td>1084 East Hall</td>
</tr>
<tr>
<td>Friday, January 23, 2015</td>
<td>3:00pm-4:00pm</td>
<td>Applied Interdisciplinary Mathematics</td>
<td>Greg Lyng (University of Wyoming) Spectral and nonlinear stability of viscous detonation waves</td>
<td>1084 East Hall</td>
</tr>
<tr>
<td>Friday, January 30, 2015</td>
<td>3:00pm-4:00pm</td>
<td>Applied Interdisciplinary Mathematics</td>
<td>Todd Kapitula (Calvin College) Reformulating spectral problems with the Krein matrix</td>
<td>1084 East Hall</td>
</tr>
<tr>
<td>Friday, February 06, 2015</td>
<td>3:00pm-4:00pm</td>
<td>Applied Interdisciplinary Mathematics</td>
<td>Alexandre Cazâ© (University of Michigan) Origins of the radiative transfer equation for light</td>
<td>1084 East Hall</td>
</tr>
<tr>
<td>Friday, February 13, 2015</td>
<td>3:00pm-4:00pm</td>
<td>Applied Interdisciplinary Mathematics</td>
<td>George Barbastathis (Massachusetts Institute of Technology) Compressive phase retrieval</td>
<td>1084 East Hall</td>
</tr>
<tr>
<td>Date</td>
<td>Time</td>
<td>Event</td>
<td>Speaker</td>
<td>Location</td>
</tr>
<tr>
<td>--------------------</td>
<td>------------</td>
<td>-----------------------------------------------------------------------</td>
<td>--------------------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>Friday, February 20, 2015</td>
<td>3:00pm-4:00pm</td>
<td><strong>Applied Interdisciplinary Mathematics</strong> -- Dinh-Liem Nguyen (University of Michigan) <em>An electromagnetic inverse scattering problem for periodic structures</em></td>
<td>1084 East Hall</td>
<td></td>
</tr>
<tr>
<td>Friday, February 27, 2015</td>
<td>3:00pm-4:00pm</td>
<td><strong>Applied Interdisciplinary Mathematics</strong> -- Adam Stinchcombe (University of Michigan) <em>A population density approach with particles</em></td>
<td>1084 East Hall</td>
<td></td>
</tr>
<tr>
<td>Friday, March 13, 2015</td>
<td>3:00pm-4:00pm</td>
<td><strong>Applied Interdisciplinary Mathematics</strong> -- J. Thomas Beale (Duke University) <em>Uniform error estimates for fluid flow with moving boundaries using finite difference methods</em></td>
<td>1084 East Hall</td>
<td></td>
</tr>
<tr>
<td>Friday, March 20, 2015</td>
<td>3:00pm-4:00pm</td>
<td><strong>Applied Interdisciplinary Mathematics</strong> -- John Lowengrub (University of California, Irvine) <em>Feedback, lineages and vascular tumor growth</em></td>
<td>1084 East Hall</td>
<td></td>
</tr>
<tr>
<td>Friday, March 27, 2015</td>
<td>3:00pm-4:00pm</td>
<td><strong>Applied Interdisciplinary Mathematics</strong> -- Shiva Rudraraju (University of Michigan (Mech. Eng.)) <em>Finite strain gradient elasticity and its application to modeling material defects and solid-solid phase transformations</em></td>
<td>1084 East Hall</td>
<td></td>
</tr>
<tr>
<td>Friday, April 03, 2015</td>
<td>3:00pm-4:00pm</td>
<td><strong>Applied Interdisciplinary Mathematics</strong> -- Ilker Kocyigit (University of Michigan) <em>Array imaging using sparse optimization in discrete and continuous settings</em></td>
<td>1084 East Hall</td>
<td></td>
</tr>
<tr>
<td>Friday, April 10, 2015</td>
<td>3:00pm-4:00pm</td>
<td><strong>Applied Interdisciplinary Mathematics</strong> -- Jonathan Hauenstein (Applied and Computational Mathematics and Statistics, Notre Dame University) <em>Parameters and polynomials</em></td>
<td>1084 East Hall</td>
<td></td>
</tr>
<tr>
<td>Friday, April 17, 2015</td>
<td>3:00pm-4:00pm</td>
<td><strong>Applied Interdisciplinary Mathematics</strong> -- Russ Caflisch (University of California, Los Angeles) <em>Applications of Information Science to PDEs</em></td>
<td>1084 East Hall</td>
<td></td>
</tr>
</tbody>
</table>
We introduce a new framework for the multiphysical modeling and multiscale computation of nano-optical responses. The semi-classical theory treats the evolution of the electromagnetic field and the motion of the charged particles self-consistently by coupling Maxwell equations with Quantum Mechanics. To overcome the numerical challenge of solving high dimensional many body Schrodinger equations involved, we adopt the Time Dependent Current Density Functional Theory (TD-CDFT). In the regime of linear responses, this leads to a linear system of equations determining the electromagnetic field as well as current and electron densities simultaneously. A self-consistent multiscale method is proposed to deal with the well separated space scales. Numerical examples are presented to illustrate the resonant condition.

The talk is concerned with the application of sensor array imaging in complex environments. The goal of imaging is to estimate the support of remote sources or strong reflectors using time resolved measurements of waves at a collection of sensors (the array). This is a challenging problem when the imaging environment is complex, due to numerous small scale inhomogeneities and/or rough boundaries that scatter the waves. Mathematically we model such complexity (which is necessarily uncertain in applications) using random processes, and thus study imaging in random media. I will focus attention on the application of imaging in random waveguides, which exhibits all the challenges of imaging in random media. I will present a quantitative study of cumulative scattering effects in such waveguides and then explain how we can use such a study to design high fidelity imaging methods.
Understanding rare events like transitions of chemical system from reactant to product states is a challenging problem due to the time scale separation. In this talk, we will discuss some recent progress in mathematical theory of transition paths. In particular, we identify and characterize the stochastic process corresponds to transition paths. The study of transition path process helps to understand the transition mechanism and provides a framework to design and analyze numerical approaches for rare event sampling and simulation.

Splashing from the impact of a liquid drop with a solid or liquid surface is an important problem with a wide range of practical applications including pesticide spraying, fuel injection systems, inkjet printing, the transfer of gases across the air-sea interface to name a few examples. It is also an experimentally and theoretically challenging physical problem. There is a bewildering variety of splash morphologies and droplet distributions which manifest as the system parameters (droplet size and speed, layer depth, fluid properties) are varied. Despite this complexity, a splash begins with the formation of a sheet-like jet. There are at least two varieties of jets: the large and slow lamella jet and the small and quick ejecta jet. In this talk I will present our progress towards understanding the simplest of splashes, the so-called crown splash, which results from the disintegration of the lamella. I will also discuss our experimental results on the ejecta jet and the role of the surrounding gas on its evolution.
Many problems in signal and image processing, machine learning, and estimation require optimization of convex cost functions. For convex cost functions with Lipschitz continuous gradients, Nesterov's fast gradient method decreases the cost function at least as fast as the square of the number of iterations, a rate order that is optimal. This talk presents a new first-order optimization method that converges twice as fast yet has a remarkably simple implementation comparable to Nesterov's method. Examples in machine learning and X-ray computed tomography (CT) will be shown. This work is from Donghwan Kim's doctoral thesis.

Although random cell complexes occur throughout the physical sciences, there does not appear to be a standard way to quantify their statistical similarities and differences. I’ll introduce the notions of a ‘swatch’ and a ‘cloth’, which provide a description of the local topology of cell complexes which is both general (any physical system that may be represented as a regular cell complex is admissible) and complete (any statistical question about the local topology may be answered from the cloth). This approach also allows a distance to be defined that measures the similarity of the local topology of two cell complexes. The distance is used to identify a steady state of a model dislocation network evolving by energy minimization, and then to quantify the approach of the simulation to this steady state.

If time permits, I will introduce two other methods of computational topology useful to the study of materials.

Advances in numerical methods and three-dimensional imaging techniques have enabled the quantification of cardiovascular mechanics in subject-specific anatomic and physiologic models. The computer modeling effort has been focused on three main applications areas: i) cardiovascular disease research, ii) medical device design and performance evaluation and iii) virtual surgical planning. The focus of this work is on the latter.

A key objective in surgical planning modeling should be the appropriate representation of the transitional stages experienced by the subject due to anesthesia, stress, blood loss, and the various regional auto-regulations mechanisms of the arterial system that seek to maintain baseline conditions of flow and pressure. Under this light, one could cast the problem of modeling the function of the cardiovascular system under transitional stages as a control system problem.

In this work we will present the key components of a computational framework that enables the simulation of cardiovascular dynamics under transitional stages. A key component of the framework is a model of the baroreflex mechanism. This mechanism couples cardiovascular and nervous systems and is responsible for dynamic adaptations of parameters such as vascular resistance and compliance, unstressed volume, heart rate, and cardiac contractility. We will demonstrate this framework under a specific transitional stage induced in the clinic known as “tilt test”.

The second part of this work focuses on another task of critical importance towards facilitating the translation of computational modeling in the clinic, namely the automatic estimation of material and boundary condition parameters used in the computer model. Currently, this task is by far the most time consuming of the modeling effort and it requires a high degree of expertise from the user. We will demonstrate a Kalman-filtering based framework for automatic estimation of cardiovascular modeling parameters.
Self-assembly, a process in which a disordered system of preexisting components forms an organized structure or pattern, is both ubiquitous in nature and important for the synthesis of many designer materials. In this talk, we will address three variational models for self-assembly from the point of view of mathematical analysis and computation.

The first is a nonlocal perturbation of Coulombic-type to the well-known Ginzburg-Landau/Cahn-Hilliard free energy. The functional has a rich and complex energy landscape with many metastable states. I will present a simple method for assessing whether or not a particular computed metastable state is a global minimizer. The method is based upon finding a "suitable" global quadratic lower bound to the free energy.

The second model is a purely geometric and finite-dimensional paradigm for self-assembly which generalizes the notion of centroidal Voronoi tessellations from points to rigid bodies. Using a level set formulation, we a priori fix the geometry for the structures and consider self-assembly entirely dictated by distance functions. I will introduce a novel fast algorithm for simulations in two and three space dimensions.

In this talk, I will discuss recent progress, and open challenges, in formally linking three scales that characterize crystal surface evolution. These scales include: (i) atomistic dynamics in the context of a stochastic lattice gas model; (ii) the motion of nanoscale line defects (steps) on surfaces; and (iii) fully continuum evolution based on parabolic-type PDEs for the surface height. In particular, I will address the microscale origin of free boundary problems for such PDEs.
The atmosphere is characterized by motions that cover a wide range of spatial and temporal scales. They range from planetary-wave scales of order $O(10,000 \text{ km})$ to mesoscales of order $O(10-100 \text{ km})$ down to microscales of order $O(1 \text{ m})$ and finer. Processes like rainfall even happen at the sub mm-scale and always need to be approximated via so-called physical parameterizations. Resolving all atmospheric processes on a computational grid is not possible in today's weather and climate models. Typically, climate models employ horizontal grid spacings of around 100 km, and thereby even have difficulty representing important mesoscale phenomena such as tropical cyclones which have a typical diameter between 500-1000 km.

One solution to this problem is the use of Adaptive Mesh Refinement (AMR) and variable-resolution techniques in atmospheric models. AMR grids can follow a feature of interests with a high-resolution nested grid as the flow evolves. Variable-resolution techniques describe static grid refinements in selected predetermined regions (e.g. an ocean basin for the study of tropical cyclones) and do not move during a forecast. The talk will first give an overview of the partial differential equations in weather and climate models. It then surveys the many mathematical design decisions that determine the accuracy of the numerical schemes and the resulting physical flow fields. Particular attention is paid to the numerical design of the AMR and variable-resolution techniques which are now emerging approaches for future-generation climate and weather models.
Fueled by our increasingly information-based and data-driven society, there is a growing need for computational methods capable of "making sense" of volumes of data that may be very high-dimensional, corrupted, or even largely incomplete. A unifying theme in many modern investigations into problems of this form is to exploit intrinsic low-dimensional structure to facilitate inference. For example, a number of recent efforts have shown that computationally tractable "robust" variants of principal component analysis methods can provably succeed in recovering data vectors originating from some common low-dimensional subspace, even when the data are corrupted by outliers and/or have many missing elements. These tools have found utility in a number of applications in machine learning, bioinformatics, image processing, and collaborative filtering, to name a few.

In this talk, we discuss some of our initial work on a related, but complimentary, task -- rather than estimate vectors in the presence of corruption or outliers, we consider the problem of identifying the locations of corrupted data points or outliers in a large, otherwise low-rank, matrix. Such problems may arise, for example, when identifying malicious responses in survey data, detecting anomalous patterns in network traffic, or even in visual surveillance applications where one seeks to locate anomalies in a scene. We propose a simple two-step adaptive sensing and inference approach to these problems, and provide theoretical guarantees quantifying its performance. Our results show that under somewhat mild assumptions, accurate outlier identification is achievable using very few linear summaries of the rows and columns of the original data matrix (as few as the squared rank of the low-rank component plus the number of outliers, times constant and logarithmic factors). More generally, our investigation shows that the sample complexity and computational burden associated with the task of identifying outliers from a structured background can be significantly less than for methods that seek to recover or estimate the structured background itself in the presence of outliers.

We demonstrate the performance of our approach experimentally on synthetic data, and in an application motivated by saliency map estimation tasks arising in computer vision and automated surveillance.
In this talk I would like to discuss methods of modeling microstructure formation on mesoscopic time scales. On mesoscopic length scales, sharp interface descriptions are often used to describe such phenomena. In this approach interfaces or domain walls are replaced with boundary conditions that are then coupled to equations used to describe bulk phenomena, such as diffusion. While such a description is quite useful it can be difficult to implement for a complex set of boundaries. To overcome this problem various methods, such as phase field modeling and the level set method, were developed to deal with the complex microstructures that emerge in everyday processes such as solidification.

While these approaches have many advantages it is often difficult to naturally incorporate atomistic features, such as dislocations, grain boundaries and crystalline anisotropy (particularly in polycrystalline materials), that can alter both microstructure formation and material properties. These features can be introduced (at a computational cost) by considering fields that vary on atomic length scales as is done in phase field crystal models. In this talk I would to discuss the connection between these different approaches and introduce the so-called amplitude approach which provides a natural bridge from phase field crystal to phase field models.
The jellyfish has been the subject of numerous mathematical and physical studies ranging from the discovery of reentry phenomenon in electrophysiology to the development of axisymmetric methods for solving fluid-structure interaction problems. In this presentation, we develop and test mathematical models describing the pulsing dynamics and the resulting fluid flow generated by the benthic upside down jellyfish, Cassiopea spp., and the pelagic moon jellyfish, Aurelia spp. The kinematics of contraction and distributions of pulse frequencies were obtained from videos and used as inputs into numerical simulations. Particle image velocimetry was used to obtain spatially and temporally resolved flow fields experimentally. The immersed boundary method was then used to solve the fluid-structure interaction problem and explore how changes in morphology and pulsing dynamics alter the resulting fluid flow. For Cassiopea, significant mixing occurs around and directly above the oral arms and secondary mouths. We found good agreement between the numerical simulations and experiments, suggesting that the presence of porous oral arms induce net horizontal flow towards the bell and mixing. For Aurelia, maximum swim speeds are generated when the elastic bell is driven at its natural frequency.
Bifurcation and competitive evolution of network morphologies in the strong Functionalized Cahn-Hilliard equation

The Functionalized Cahn-Hilliard (FCH) energy is a higher-order free energy for blends of amphiphillic polymers and solvent which balances solvation energy of ionic groups against elastic energy of the underlying polymer backbone. Its gradient flows describe the formation of solvent network structures which are essential to ionic conduction in polymer membranes. The FCH energy possesses stable, coexisting network morphologies and we characterize their geometric evolution, bifurcation and competition through a center-stable manifold reduction which encompasses a broad class of coexisting network morphologies. The stability of the different networks is characterized by the meandering and pearling modes associated to the linearized system. For the $H^{-1}$ gradient flow of the FCH energy, using functional analysis and asymptotic methods, we drive a sharp-interface geometric motion which couples the flow of co-dimension 1 and 2 network morphologies, through the far-field chemical potential. In particular, we derive expressions for the pearling and meander eigenvalues for a class of far-from-self-intersection co-dimension 1 and 2 networks, and show that the linearization is uniformly elliptic off of the associated center stable space.

The moving contact line in viscous thin films: a singular free boundary problem

We are interested in the thin-film equation with quadratic mobility and zero contact angle, modeling the height of a viscous thin-film with a linear Navier-slip condition at the liquid-solid interface. This degenerate-parabolic fourth-order problem has the contact line (the triple junction between the three phases liquid, gas, and solid) as a free boundary. Starting with the analysis of source-type self-similar solutions, we conclude that solutions cannot be expected to be smooth and explicitly characterize the singular expansion of such solutions at the free boundary. With this understanding, we are able to prove a well-posedness result of the corresponding full parabolic problem. We conclude the talk with an overview of other questions and results, such as the generalization to thin-film equations with general mobility, higher regularity, the convergence to the source-type self-similar solution, or asymptotics related to Tanner's law. Many of the presented results are joint with Lorenzo Giacomelli, Hans Knüpfer, and Felix Otto.
Applied Interdisciplinary Mathematics
Friday, January 23, 2015, 3:00pm-4:00pm
1084 East Hall
Greg Lyng (University of Wyoming)
Spectral and nonlinear stability of viscous detonation waves

In this talk, we outline a program, combining analytical and numerical Evans-function techniques, for evaluating the spectral and nonlinear stability of viscous detonation waves. In the relatively simple case of Majda's qualitative combustion model, this program has been completely carried out, and we show how to obtain nonlinear stability results for both strong (Lax-type) and weak (under compressive) detonation waves. Finally, we discuss the extension of this program to the physically relevant case of the Navier-Stokes equations modeling a compressible mixture of reacting gases. The results in this case are surprising.

Applied Interdisciplinary Mathematics
Friday, January 30, 2015, 3:00pm-4:00pm
1084 East Hall
Todd Kapitula (Calvin College)
Reformulating spectral problems with the Krein matrix

Successful resolution of spectral problems in Hamiltonian systems requires not only that we locate the eigenvalues, but also that we determine the Krein signatures of those which are purely imaginary. The well-known Evans function determines the location and multiplicity of the eigenvalues, but in its classical form it does not allow a determination of the signatures. On the other hand, the Krein matrix, and the accompanying Krein eigenvalues, allow us to not only find the eigenvalues, but the graphs can be used to determine the signatures. We will briefly consider the construction of the matrix, and discuss its role in applications.
In complex inhomogeneous media, such as clouds or milk, the mathematical description of light propagation varies depending on the scale one is interested in. At the scale of the optical wavelength, the Maxwell equations hold and the electric field satisfies a wave equation. At larger scales, light intensity propagation is described by the Radiative Transfer Equation (RTE), that stems from a phenomenological approach analog to Boltzmann's kinetic laws for gas. In this talk, we will derive the RTE from the scalar wave equation using two different approaches. The first method is based on diagrammatic perturbation theory, while the second stems from an asymptotic multiscale expansion. Although the two method are quite distinct mathematically, some common ground can be found and is discussed.

Compressive sensing is a class of image recovery techniques utilizing sparsity priors to recover undersampled signals with high fidelity. This talk is about compressive sensing for phase retrieval from coherent fields and correlation function retrieval from partially coherent fields. For coherent fields, I will discuss in particular the use of intensity priors in the "transport of intensity equation" method, where the phase is obtained by analogy to a lateral pressure potential in a compressible flow. Transport of intensity is especially interesting in the x-ray regime, where standard interferometry is difficult because common sources are spatially partially coherent and beam splitters-combiners are not available; as a convincing example, I will show how the sparsity prior of quasi-constant object density allows successful x-ray phase recovery despite the low coherence. For partially coherent fields, I will describe how the use of phase-space (Wigner space) methods and sparsity priors on the number of coherent modes allow the retrieval of the correlation function, which can still lead to complete characterization of physical objects.
We consider the problem of shape reconstruction in inverse scattering of time-harmonic electromagnetic waves for periodic structures. We are interested in a class of periodic structures which are known as diffraction gratings. They are encountered in applications in optics such as diffractive optical filters and organic light-emitting diodes. The shape reconstruction problem under consideration, motivated by applications of non-destructive testing, can be formulated as an inverse problem. More precisely, given measurements of the scattered fields for a number of incident fields, we aim to reconstruct shape of the grating. We investigate the Factorization method introduced by A. Kirsch as an analytical as well as a numerical tool for solving this inverse problem. This method constructs a necessary and sufficient criterion whether a given point in space lies inside or outside the penetrable periodic structure, yielding a uniqueness result and a fast imaging algorithm. In this talk we will discuss the justification of the Factorization method as well as some numerical examples showing the efficiency of the method.
According to the population density approach, instead of tracking the state of each oscillator in a large population as they evolve according to ordinary differential equations, one may consider the primary variable of interest to be the population density over state space. After accounting for additive Gaussian noise and coupling within the population, the population density is governed by a non-linear and non-local integro-advection-diffusion differential equation. When the state space has many dimensions, it appears that nothing has been gained by trading a large number of state variables for a differential equation with a large number of dimensions. We exploit the fact that the population of limit cycle oscillators, or even chaotic oscillators, occupy only a small amount of the state space. An efficient numerical method for solving the governing equation for the population density results from discretizing over particles in a grid-free approach and utilizing a diffusion velocity method. We are thus permitted to study the dynamics of a population of noisy coupled oscillators without having to resort to dimension reduction strategies. We can consider detailed oscillator models involving physical variables. In this talk, I will detail our numerical method and present its application to a model of a population of neurons and a population of coupled biochemical oscillators.

Recently there has been extensive development of numerical methods for fluid flow interacting with moving boundaries or interfaces, using regular finite difference grids which do not conform to the boundaries. Simulations at low Reynolds number have demonstrated that, with certain choices in the design of the method, the velocity can be accurate to about $O(h^2)$ while discretizing near the interface with truncation error as large as $O(h)$. We will describe error estimates which verify that such accuracy can be achieved in a simple prototype problem, even near the interface, using corrections to difference operators as in the immersed interface method. We neglect errors in the interface location and derive uniform estimates for the fluid velocity and pressure. We will first discuss maximum norm estimates for finite difference versions of the Poisson equation and diffusion equation with a gain of regularity. We will then describe the application to the Navier-Stokes equations.
Cancer arises when the carefully regulated balance of cell proliferation and programmed cell death (apoptosis) that ordinarily exists in normal homeostatic tissues is disrupted. Cancer cells are assumed to acquire a common set of traits. However, not all the cells in a tumor seem to matter equally and tumor cells progress through lineage stages regulated by feedback pathways. It is known that the microenvironment plays an important role in this regulation. Secreted factors by vascular endothelial cells (ECs) have been found to support and maintain cancer stem cells (CSCs) and it has even been observed that CSCs can transdifferentiate into ECs. It has been hypothesized that transdifferentiated ECs may contribute to tumor vascularization via vasculogenesis. However, these processes are not well understood and mathematical modeling can provide insight on the underlying biology. We use a hybrid continuum-discrete multispecies mathematical model to simulate numerically the three-dimensional spatiotemporal dynamics of hierarchically-structured, vascularized solid tumors. Tumor cells and substrate species are treated as continuum, while vessels are treated as discrete quantities. We account for protein factors secreted by tumor cells and ECs that affect angiogenesis, tumor cell self-renewal, differentiation and transdifferentiation, and proliferation pathways. By testing different combinations, our models reveal the effects of feedback regulation on tumor size, invasiveness as well as on the heterogeneous distribution of cells within the tumor and the structure of the vascular network. Consistent with experimental observations, positive feedback from the ECs to the CSCs creates perivascular niches and increases the CSC fractions in the tumor as well as the tumor sizes and the amount of functional vasculature. Intratumoral vasculogenesis is found to result from transdifferentiation of CSCs into ECs, thereby increasing tumor sizes further. Negative regulation by ECs on CSCs transdifferentiation is paradoxically found to increase tumor sizes, CSC fractions and vasculogenesis. Thus cross-talk between the tumor and the vasculature plays a critical role in tumor progression, heterogeneity, vascularity and the development of morphological instability. By systematically testing the effect of different feedback mechanisms, the model predicts behavior that can be tested experimentally. The close interactions between tumor cells and the vascular network present opportunities and challenges for therapeutic intervention.
Applied Interdisciplinary Mathematics
Friday, March 27, 2015, 3:00pm-4:00pm
1084 East Hall
Shiva Rudraraju (University of Michigan (Mech. Eng.))
*Finite strain gradient elasticity and its application to modeling material defects and solid-solid phase transformations*

Classical theory of (hyper-) elasticity assumes the elastic free energy density to be a frame-invariant function of the deformation gradient. However, higher order gradients of the deformation map become prominent in applications involving martensitic like phase transformations, materials defects, dislocations, cracks, etc. In such cases the elastic free energy density must be extended to include strain gradients and the resulting formulation is a gradient theory of elasticity whose foundations were laid down in the 1960's. However, significant numerical challenges have rendered this problem computationally intractable until recently. We present the first complete three-dimensional numerical solutions to a broad range of boundary value problems for a general theory of finite strain gradient elasticity, and discuss the role of higher-order boundary conditions, length scale effects and the relevance of the framework to problems with solid-solid phase transformations and material defects. This is joint work with Krishna Garikipati and Anton Van der Ven (UCSB).

Applied Interdisciplinary Mathematics
Friday, April 03, 2015, 3:00pm-4:00pm
1084 East Hall
Ilker Kocyigit (University of Michigan)
*Array imaging using sparse optimization in discrete and continuous settings*

Recently there have been works where the ideas from compressive sensing are applied to the sparse imaging problem where the sources or scatterers are assumed to be sparse. In this talk we present some of these sparse optimization methods and how they are applied to the array imaging problem. We discuss the relation between the sparsity of the unknown localized sources and unique recoverability of the image in the discrete setting. Then our goal is to apply these ideas to the imaging problem in the continuous setting, where we discuss discretization error, the conditions of unique recoverability, and also the reconstruction when the uniqueness and exact reconstruction condition doesn’t hold. We also present some numerical simulations. This talk is based on a current work with Liliana Borcea.
Parameters and polynomials

A model can typically have different behavior in various regions of a parameter space. For example, for one set of the parameters, the model could have no steady-state solutions while, in another region of the parameter space, it could have multiple stable steady-state solutions. This talk will explain how computational techniques in the area of numerical algebraic geometry can help one understand the parameter space for a nonlinear model. These techniques will be applied to various models, including the Kuramoto model and a long-term memory model.

Applications of Information Science to PDEs

The arrival of massive amounts of data from imaging, sensors, computation and the internet brought with it significant challenges for information science. New methods for analysis and manipulation of big data have come from many scientific disciplines. The first focus of this presentation is the application of ideas from PDEs, such as variational principles and numerical diffusion, to image and data analysis. Examples include denoising, segmentation, inpainting and texture extraction for images. The second focus is the development of new ideas in information science, such as soft-thresholding, sparsity and compressed sensing. The subsequent application of these ideas to PDEs and numerical computation is the third focus of this talk. Examples include soft-thresholding in multiscale computation, solutions with compact support and "compressed modes" for PDEs that come from variational principles, and applications to density functional theory.