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<tr>
<th>Date</th>
<th>Event</th>
<th>Time</th>
<th>Speaker</th>
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<tr>
<td>Friday, January 08, 2016</td>
<td></td>
<td>3:00pm-4:00pm</td>
<td>Applied Interdisciplinary Mathematics -- Diego Ayala Rodriguez (University of Michigan)</td>
<td>Extreme vortex states in hydrodynamic systems</td>
<td>1084 East Hall</td>
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<td>Friday, January 15, 2016</td>
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<td>3:00pm-4:00pm</td>
<td>Applied Interdisciplinary Mathematics -- Michal Żochowski (University of Michigan)</td>
<td>How can cognitive processes in the brain be regulated by changing properties of individual cells?</td>
<td>1084 East Hall</td>
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<td>Friday, January 22, 2016</td>
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<td>3:00pm-4:00pm</td>
<td>Applied Interdisciplinary Mathematics -- Robert Kerr (University of Warwick)</td>
<td>Helicity annihilation in trefoil reconnection: simulations</td>
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<td>Friday, January 29, 2016</td>
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<td>3:00pm-4:00pm</td>
<td>Applied Interdisciplinary Mathematics -- Andreas Blass (University of Michigan)</td>
<td>Some aspects of quantum computation</td>
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<td>Friday, February 05, 2016</td>
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<td>3:00pm-4:00pm</td>
<td>Applied Interdisciplinary Mathematics -- Steve Cundiff (University of Michigan)</td>
<td>Nonlinear pulse dynamics in modelocked lasers</td>
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<td>Friday, February 12, 2016</td>
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<td>3:00pm-4:00pm</td>
<td>Applied Interdisciplinary Mathematics -- Amy Cochran (University of Michigan)</td>
<td>Mathematical classification of bipolar disorder from longitudinal mood data</td>
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<td>Friday, February 19, 2016</td>
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<td>3:00pm-4:00pm</td>
<td>Applied Interdisciplinary Mathematics -- Andrew Christlieb (Michigan State University)</td>
<td>Steps towards a fast O(N) approach for direct inversion of linear operators with applications to nonlinear partial differential equations</td>
<td>1084 East Hall</td>
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<td>Friday, February 26, 2016</td>
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<td>3:00pm-4:00pm</td>
<td>Applied Interdisciplinary Mathematics -- Karl Liechty (DePaul University)</td>
<td>The Fourier continuation method and discrete orthogonal polynomials on an arc</td>
<td>1084 East Hall</td>
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<td>Friday, March 11, 2016</td>
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<td>3:00pm-4:00pm</td>
<td>Applied Interdisciplinary Mathematics -- Eitan Tadmor (University of Maryland, College Park)</td>
<td>Collective dynamics: from emergence of consensus to social hydrodynamics</td>
<td>1084 East Hall</td>
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<td>Friday, March 18, 2016</td>
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<td>3:00pm-4:00pm</td>
<td>Applied Interdisciplinary Mathematics -- Ihsan Topaloglu (McMaster University)</td>
<td>Nonlocal energies defined via attractive-repulsive interaction potentials</td>
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<td>Friday, March 25, 2016</td>
<td>3:00pm</td>
<td><strong>Applied Interdisciplinary Mathematics</strong> -- Rita Gitik (University of Michigan)</td>
<td><strong>Generation theory:</strong> application to the genography problem</td>
<td>1084 East Hall</td>
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<td>Friday, April 01, 2016</td>
<td>3:00pm</td>
<td><strong>Applied Interdisciplinary Mathematics</strong> -- Howard Stone (Princeton University (Mech. Eng.))</td>
<td><strong>Elementary channel flows with surprising response:</strong> (i) Biofilms and flow and (ii) Trapping of bubbles in stagnation point flows</td>
<td>1084 East Hall</td>
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<td>Friday, April 08, 2016</td>
<td>3:00pm</td>
<td><strong>Applied Interdisciplinary Mathematics</strong> -- AVAILABLE ()</td>
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<td>1084 East Hall</td>
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<td>Friday, April 15, 2016</td>
<td>3:00pm</td>
<td><strong>Applied Interdisciplinary Mathematics</strong> -- Joel Tropp (Caltech)</td>
<td><strong>TBA</strong></td>
<td>1084 East Hall</td>
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Abstracts

Applied Interdisciplinary Mathematics
Friday, January 08, 2016, 3:00pm-4:00pm
1084 East Hall
Diego Ayala Rodriguez (University of Michigan)

Extreme vortex states in hydrodynamic systems

By numerically solving suitable constrained optimization problems, we assess
the sharpness of analytic estimates for the instantaneous rate of growth and the finite-time
growth of certain norms of solutions to the Navier-Stokes equation in 2 and 3 dimensions.
Connections with the problem of finite-time singularity formation in the three-dimensional case
are addressed.

Applied Interdisciplinary Mathematics
Friday, January 15, 2016, 3:00pm-4:00pm
1084 East Hall
Michal Zochowski (University of Michigan)

How can cognitive processes in the brain be regulated by changing properties of individual cells?

The brain is a complex and evolving network. While a lot is known about its biology, the dynamical principles
underlying information processing in the brain remain elusive. However, it becomes apparent that to
understand dynamics of brain function one has investigate the effects of dynamical properties of individual cells
on network-wide spatio-temporal pattern formation. In this talk I will use example of neuromodulatory effects of
Achetycholine (Ach) on individual neurons, to underscore the link between changing cellular properties and
evolving network dynamics with their possible implication for brain function. Ach, being one of multitude of
neuromodulators in the brain, has multifaceted effects of neuronal excitabilty that thought to be especially
important during regulation of sleep/wake cycle and also during attention. I will use network models to detangle
these effects on the network level, and highlight their possible respective roles for information processing.
The simulated evolution and self-reconnection of a perturbed trefoil vortex knot is compared to the Scheeler et al, PNAS 111 (2014) experiment. To have a single initial reconnection, as in the experiments, the trefoil is perturbed by 4 weak vortex rings. Visualizations show that the simulations and experiments undergo similar topological changes. Quantitative comparisons using the helicity and global topological number show that both are preserved for a long period before reconnection begins, as in the experiments. Unlike the experiments, once reconnection begins, a significant fraction of the helicity is dissipated and the global topological number changes by a discrete amount in a fixed time. Helicity spectra and physical space correlations show that the change in helicity is associated with the appearance of negative helicity at lower wavenumbers and in the outer regions of the trefoil. Furthermore, using a range of Reynolds numbers, with the highest comparable to the experiments, it is demonstrated that a Reynolds number independent fraction of the initial helicity is dissipated in a finite time. This observation does not violate any current mathematics restricting the strong growth of Navier-Stokes norms as the viscosity goes to zero due to the structure of the trefoil. In addition, because the self-linking is exactly the integral of the velocity of one parallel trajectory on the other, is the sum of the writhe+twist of the single trajectory and is conserved until reconnection, it says that the proper self-induced Biot-Savart velocity of a trajectory is not the usual Biot-Savart integral plus a local induction correction. Instead it is the writhe+twist, that is the Biot-Savart integral plus the twist and in this form, there might be a singularity.

In principle, some computational problems can be solved more effectively if computers take advantage of quantum phenomena. Superposition of states in quantum mechanics allows for a sort of large-scale parallel computation. In practice, there are major obstacles on the road to physical realization of quantum computation on a useful scale. Nevertheless, work is proceeding on the design of quantum algorithms and on ways to implement them while dodging the errors that afflict any manipulation of extremely small entities. I'll first summarize the relevant background and then describe some of the work that I've either been involved in or observed at close hand.
Applied Interdisciplinary Mathematics  
Friday, February 05, 2016, 3:00pm-4:00pm  
1084 East Hall  
Steve Cundiff (University of Michigan)  
Nonlinear pulse dynamics in modelocked lasers

Modelocked lasers can serve as an ideal "playground" for studying nonlinear pulse dynamics. I will first introduce modelocked lasers and their description as a realization of a dissipative soliton. I will then present three phenomena that have been experimentally observed in modelocked lasers: polarization locked vector solitons, exploding solitons and verification of the "area" theorem for dispersion managed solitons. Finally, I will introduce the concepts of frequency combs and the nonlinear dynamics are driven by quantum noise to determine the quality of the combs produced by modelocked lasers.

Applied Interdisciplinary Mathematics  
Friday, February 12, 2016, 3:00pm-4:00pm  
1084 East Hall  
Amy Cochran (University of Michigan)  
Mathematical classification of bipolar disorder from longitudinal mood data

Bipolar disorder is a chronic disease of mood instability. Longitudinal patterns of mood are central to any patient description, but are condensed into simple attributes and categories. Although these provide a common language for clinicians, they are not supported by empirical evidence. In this talk, I present patient-specific models of mood in bipolar disorder that incorporate existing longitudinal data. In the first part, I will describe mood as a Bayesian nonparametric hierarchical model that includes latent classes and patient-specific mood dynamics given by discrete-time Markov chains. These models are fit to weekly mood data, revealing three patient classes that differ significantly in attempted suicide rates, disability, and symptom chronicity. In the second part of the talk, I discuss how combined statistical inferences from a population do not support widely held assumptions (e.g. mood is one-dimensional, rhythmic, and/or multistable). I then present a stochastic differential equation model that does not make any of these assumptions. I show that this model accurately describes the data and that it can be personalized to an individual. Taken together, this work moves forward data-driven modeling approaches that can guide future research into precise clinical care and disease causes.
Steps towards a fast O(N) approach for direct inversion of linear operators with applications to nonlinear partial differential equations

Multi-scale problems in science and engineering require accurate implicit methods for solving partial differential equations. However, in the world of distributed multi-core computing, a key bottleneck is the inversion of matrices. Hence, implicit solutions to partial differential equations have difficulty scaling on these computing platforms. Our goal is to develop a fast O(N) direct approach to the inversion of linear operators in real space.

The work is based on the method of lines transpose which combines Green's function methods, successive convolution, fast summation and Rothe's method. The method may also be expressed as an efficient approach for direct evaluation of pseudodifferential operators. Practically speaking, the formulation of the method based on successive convolution can be directly expressed as an O(N) method for computing the resolvent expansion of a pseudodifferential operator in real space. This method has been used to develop an A-stable arbitrary order method for solving the two way wave equation, Maxwell's equations and both linear and nonlinear parabolic problems. We are current working to extend these methods to high-order phase field models.

The Fourier continuation method and discrete orthogonal polynomials on an arc

The Fourier continuation method is a numerical method used to estimate a function from a discrete sample using Fourier techniques. It turns out that the error estimates in this method are closely connected with polynomials orthogonal with respect to a discrete weight on an arc of the unit circle. I will discuss the asymptotic properties of these polynomials, and their implications for the Fourier continuation method.
We discuss the collective dynamics of systems driven by "social engagement" of agents with their local neighbors. Prototypical examples which involve environmental averaging include alignment-based models in opinion dynamics, flocking, self-organization of biological organisms, and rendezvous in mobile networks. We address two natural questions which arise in this context. First, how different rules of engagement influence the formation of large time, large scale patterns such as clusters, and in particular, the emergence of "consensus". We propose an alternative paradigm based on the tendency of agents "to move ahead" which leads to the emergence of leaders. Second, the group behavior of systems which involve a large number of agents lend themselves to kinetic and hydrodynamic descriptions. It is known that if smooth solutions of "social hydrodynamics" exist, then they must flock. Do such smooth solutions exist? Alignment-based models reflect the competition on resources, and left unchecked, may lead to finite-time singularities. We discuss the global regularity of social hydrodynamics for sub-critical initial configurations.

A variety of physical and biological interaction - from self-assembly of nano particles to collective behavior of many-agent systems such as biological swarming - can be modeled via a nonlocal energy. Depending on the choice of the interaction kernel, the asymptotic states of these physical and biological systems can be characterized as minimizers of such energies via a gradient flow connection. In this talk, first, I will present on a joint project with Katy Craig where we show that regularization of singular attractive-repulsive kernels allows us to restore convexity and differentiability; hence enables us to understand the minimizers and the gradient flows of these energies. Next, I will consider the minimization of these energies over sets. Although this nonlocal shape optimization problem poses additional challenges I will discuss the existence/nonexistence of minimizers on certain parameter regimes and present on recent results joint with Almut Burchard and Rustum Choksi.
The generation theory was developed as a tool for studying self-reproducing systems. In this talk we show how this theory can be applied to study a search for common ancestors of living organisms. We give two algorithms with flowcharts in pseudocode for finding the common ancestors of a set of microbes and describe the connections with the genography problem.

In this talk I describe two distinct problems that we have studied where seemingly modest variations in an elementary channel flow produce new effects. First, we investigate influences of flow on biofilms. In particular, we identify the formation of biofilm streamers, which are filaments of biofilm extended along the central region of a low Reynolds number channel flow, and show how these filaments are capable of causing catastrophic disruption and clogging. We present a mathematical model to rationalize the rapid growth of the streamer. Second we consider flow in a T-junction, which is perhaps the most common element in many piping systems. In this example, the flows are laminar but have high Reynolds numbers, typically Re=100-1000. It seems obvious that any particles in the fluid that enter the T-junction will leave following the one of the two main flow channels. Nevertheless, we report experiments that document that bubbles and other low density objects can be trapped at the bifurcation. The trapping leads to the steady accumulation of bubbles that can form stable chain-like aggregates in the presence of surfactants, or give rise to a growth due to coalescence. Our three-dimensional numerical simulations rationalize the mechanism behind this phenomenon.
Applied Interdisciplinary Mathematics
Friday, April 15, 2016, 3:00pm–4:00pm
1084 East Hall
Joel Tropp (Caltech)

TBA