UNIVERSITY OF MICHIGAN
Department of Mathematics

Seminar & Events Bulletin: Student AIM Seminar

01-01-2013 to 06-30-2013

Wednesday, January 16, 2013	
3:00pm-4:00pm	**Student AIM Seminar** -- () *Planning Meeting* -- 4088 East Hall

Wednesday, January 23, 2013	
3:10pm-4:00pm	**Student AIM Seminar** -- Bobbie Wu (University of Michigan) *Fractal Image Compression* -- 4088 East Hall

Wednesday, January 30, 2013	
3:10pm-4:00pm	**Student AIM Seminar** -- Brittan Farmer (University of Michigan) *Interatomic forces* -- 4088 East Hall

Wednesday, February 06, 2013	
3:10pm-4:00pm	**Student AIM Seminar** -- () *No Talk. Reminder: SIAM Student Conference This Saturday, Feb 9, 1360 EH, 10:00am* -- 4088 East Hall

Wednesday, February 13, 2013	
3:10pm-4:00pm	**Student AIM Seminar** -- Andre Souza (University of Michigan) *Boussinesq Convection* -- 4088 East Hall

Wednesday, February 20, 2013	
3:10pm-4:00pm	**Student AIM Seminar** -- Olivia Walch (University of Michigan) *Critical Exponents* -- 4088 East Hall

Wednesday, February 27, 2013	
3:10pm-4:00pm	**Student AIM Seminar** -- Yee Chee See (University of Michigan) *Turbulent Combustion Modeling* -- 4088 East Hall

Wednesday, March 06, 2013	
3:10pm-4:00pm	**Student AIM Seminar** -- () *Spring Break. No Talk* -- 4088 East Hall

Wednesday, March 13, 2013	
3:10pm-4:00pm	**Student AIM Seminar** -- Xiaolin Wang (University of Michigan) *A numerical study of vorticity-enhanced heat transfer* -- 4088 East Hall

Wednesday, March 20, 2013	
3:10pm-4:00pm	**Student AIM Seminar** -- Hamed Razavi (University of Michigan) *Bipedal Robots* -- 4088 East Hall

Wednesday, March 27, 2013	
3:10pm-4:00pm	**Student AIM Seminar** -- Yen Ting Lin (University of Michigan) *On Interaction between Stochasticity and Nonlinearity: In the Context of Stochastic Competitive Population Dynamics* -- 4088 East Hall

Wednesday, April 03, 2013	
3:10pm-4:00pm	**Student AIM Seminar** -- Alfredo Wetzel (University of Michigan) *Whitham Modulation Theory* -- 4088 East Hall

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Wednesday, April 10, 2013	
3:10pm-4:00pm	**Student AIM Seminar** -- Richard B. Choroszucha (University of Michigan) *Linear Model Order Reduction In Model Predictive Control* -- 4088 East Hall

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Abstracts

Student AIM Seminar
Wednesday, January 16, 2013, 3:00pm-4:00pm
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()
Planning Meeting

Student AIM Seminar
Wednesday, January 23, 2013, 3:10pm-4:00pm
4088 East Hall
Bobbie Wu (University of Michigan)
Fractal Image Compression

Fractal image compression is an image compression algorithm that reduces redundancy by detecting and encoding self-similarities in an image. While the encoding time is comparatively lengthy, this compression method possess the built-in feature of "resolution-independence", which provides a way to zoom in on images. In this talk, we will present a naive schema of fractal coding, along with the mathematical theory behind the algorithm.

Student AIM Seminar
Wednesday, January 30, 2013, 3:10pm-4:00pm
4088 East Hall
Brittan Farmer (University of Michigan)
Interatomic forces

To understand the structure of molecules or the dynamics of atoms within a material, it is essential to understand the attractive and repulsive forces that exist between atoms. I will describe the Lennard-Jones potential and the Brenner potential and explain the structures they predict. I will mention the application of these forces to molecular dynamics simulation and show some illustrative examples. This talk will be accessible to all graduate students.

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Student AIM Seminar
Wednesday, February 13, 2013, 3:10pm-4:00pm
4088 East Hall
Andre Souza (University of Michigan)
Boussinesq Convection

The Boussinesq equations have long served as a model for understanding turbulent heat transport. In this talk the motivation behind the equations as well as some recent results with regards to the asymptotic scaling of heat transport will be discussed. Some numerical methods for computing stationary solutions to the equations will also be mentioned. This talk should be accessible to all math graduate students.

Student AIM Seminar
Wednesday, February 20, 2013, 3:10pm-4:00pm
4088 East Hall
Olivia Walch (University of Michigan)
Critical Exponents

Let $\mathcal{P}$ be a class of matrices, and let A be an m-by-n matrix in the class; consider some continuous powering, $A^{\{t\}}$. The critical exponent of $\mathcal{P}$, if it exists, with respect to the powering is the lowest power $g(\mathcal{P})$ such that for any matrix $B \in \mathcal{P}$, $B^{\{t\}} \in \mathcal{P} \ \forall \ t > g(\mathcal{P})$. For powering relative to matrix multiplication in the traditional sense, hereafter referred to as \emph{conventional} multiplication, this means that A^t is in the specified class for all $t > g_C(\mathcal{P})$. For Hadamard multiplication, similarly, $A^{(t)}$ is in the class $\forall \ t > g_H(\mathcal{P})$. We consider two questions for several classes $\mathcal{P}$ (including doubly nonnegative and totally positive): 1) does a critical exponent $g(\mathcal{P})$ exist? and 2) if so, what is it? For those where no exact result has been determined, lower and upper bounds are provided.

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Student AIM Seminar
Wednesday, February 27, 2013, 3:10pm-4:00pm
4088 East Hall
Yee Chee See (University of Michigan)
Turbulent Combustion Modeling

Numerical simulation is an invaluable tool in the development of cleaner combustion technology as it can provide full characterization of the flow field inside an engine.
However, obtaining an accurate numerical prediction of the combustion process inside an engine can be difficult. This is because the process is inherently multi-physics in nature and usually occurs in a turbulent flow.
To fully resolve these effects in a realistic engine is computationally prohibitive so they are generally accounted for in simulation using turbulent combustion model. The models that are currently being used in practice span a wide range of fidelity.
Nevertheless, most models seek to reduce the complexity of chemistry while capturing the interaction between chemistry and turbulence. In this talk, I will present several turbulent combustion models and their assumptions. Only rudimentary understanding of flow physics and chemistry is required to grasp the materials presented in this talk.

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Spring Break. No Talk

Student AIM Seminar
Wednesday, March 13, 2013, 3:10pm-4:00pm
4088 East Hall
Xiaolin Wang (University of Michigan)
A numerical study of vorticity-enhanced heat transfer

The Glezer lab at Georgia Tech has found that vorticity produced by vibrated reeds can improve heat transfer in electronic hardware. Vortices enhance forced convection by boundary layer separation and thermal mixing in the bulk flow. In this work, we simulate the heat transfer process in a 3-dimensional plate-fin heat sink. We propose a simplified model by considering flow and temperature in a 2-D channel. We simulate periodically steady-state solutions. We classify several types of the vortex street and determine how the global Nusselt number is increased, depending on the vortices' strengths and spacings, in the parameter space of Reynolds and Peclet numbers.

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Student AIM Seminar
Wednesday, March 20, 2013, 3:10pm-4:00pm
4088 East Hall
Hamed Razavi (University of Michigan)
Bipedal Robots

More than 50 percent of the earth's landmass is terrain that is too rough for the wheeled vehicles to access! This is one of the reasons that scientists are trying to develop legged robots, which unlike wheeled vehicles can use isolated footholds that optimize support and traction. However, controlling legged robots in a way that they are stable and at the same time have a high level of mobility is known to be very difficult. This is mostly due to a lack in theory rather than technology!

In this talk, I explain the problem of bipedal robot control and some of the methods that have been used to solve the problem. I show some videos of MABEL, a biped robot at University of Michigan. Also, I will show the simulations of a three dimensional robot I've been working on recently.

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Student AIM Seminar
Wednesday, March 27, 2013, 3:10pm-4:00pm
4088 East Hall
Yen Ting Lin (University of Michigan)

On Interaction between Stochasticity and Nonlinearity: In the Context of Stochastic Competitive Population Dynamics

Biological dispersal is a classic problem in mathematical biology. One of the core question is, whether there exists an evolutionarily stable (ES) strategy for dispersion. In the deterministic models with passive diffusion, it has been proven that no dispersal is evolutionary stable. However, recent numerical studies showed that demographic fluctuation would enhance dispersal, and the underlying mechanism of the enhancement had not been identified.

This talk will start with heuristic examples, along with one published numerical study by Kessler and Sander in `09, to describe of the problems of interests. After the context is set up, I will present two models we developed to investigate the problem. The objective is to explore whether the evolutionarily stable dispersal rate exists, and if so, how it functionally depends on various parameters of the systems.

This topic is a continuation of our previous proposed "live-fast-die-young" (LFDY) model, which was presented by Prof. Doering in the AIM seminar in January. I will show that, combining the novel asymptotic analysis we proposed in the LFDY-model with a conventional asymptotic analysis, we are able to obtain closed forms of asymptotic solutions of both the dispersal models. Numerical evidence will be presented to support our analysis. I will present the insight of the dynamical mechanisms, which is hinted in the mathematical expressions: the outcome of the competition are due to the nonlinearity and the stochasticity of the system at a high order of asymptotic expansion.

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Student AIM Seminar
Wednesday, April 03, 2013, 3:10pm-4:00pm
4088 East Hall
Alfredo Wetzel (University of Michigan)
Whitham Modulation Theory

Whitham modulation or modulation theory describes the evolution of slowly modulated wave-trains of nonlinear, dispersive partial differential equations (PDEs). In practice, this involves considering the PDE in a certain asymptotic limit so that quantities such as the wavenumber, phase speed, amplitude, etc. of the solution are locally well defined. The theory then consists in obtaining evolution equations, arising from the PDE, for these parameters: the modulation equations. These modulation equations may be found through multiple-scale expansions, through the averaging of conservation laws, or the averaging of the Lagrangian of the system. The method is grounded on intuition and remarkably useful in physical applications such as dispersive shock waves.

I will begin the talk with physical examples of dispersion and the mathematics used to study dispersive waves. I will then discuss the foundations of modulation theory and the construction of the modulation equations. I will finish by showing an application of Whitham modulation theory to solve a dispersive shock problem in a manner akin to the method of matched asymptotic expansions used in ODEs. The talk is intended to be mostly self-contained.

Student AIM Seminar
Wednesday, April 10, 2013, 3:10pm-4:00pm
4088 East Hall
Richard B. Choroszucha (University of Michigan)
Linear Model Order Reduction In Model Predictive Control

Model order reduction (MOR) is a common task for model-based control design, specifically for those where a copy of the plant model appears explicitly in the resulting controller. This is done to reduce the number of states and thereby the complexity because plant model complexity dictates the controller complexity and robustness. For computationally intensive optimization-based control, such as model predictive control (MPC), MOR is essential to ensure that the controller is implementable on hardware, especially for applications where the computational resources, such as memory and power, are limited and fast sampling is required.

The problem is that most MOR techniques are meant to be applied to a class of model - stable, unstable, passive, dissipative, etc. - without consideration to the control formulation.

This talk will consist of a brief overview of MPC, the techniques and theoretical tools of linear MOR, and then a novel reduction method that accounts for the MPC control formulation.