Book of Abstracts

Parallel Sessions, Friday, September 20, 2019

Room 110

Julia Arciero, Indiana University-Purdue University Indianapolis, jarciero@iupui.edu

Title: Maximizing the potential of Treg-based therapies for transplant rejection via mathematical modeling: effect of dose, timing, and distribution

Abstract: Organ transplantation is the only life-saving procedure that restores the function of a failing organ. However, transplant patients must remain on immunosuppressive drugs for their lifetime, causing them to be at an increased risk for infections and other health complications (including rejection). Alternative treatment strategies that promote transplant acceptance without compromising the patient's immune system, such as the adoptive transfer of regulatory T cells (Tregs), are thus greatly needed. Mathematical modeling offers a valuable method for identifying conditions that will maximize the potential of Tregs to promote graft survival. Here, strategies for the adoptive transfer of Tregs are theorized using an experimentally-based ODE model of the immune response to murine heart transplants. The timing of dosing, dosing rate, activation status of Tregs, and site of accumulation post-injection are all factors that are assessed using the model. Model results suggest that activated Tregs administered to the graft site are most effective at extending graft survival. Varying the day on which a single dose of Tregs is administered yields an unexpected non-monotonic relationship with survival time of the graft: within a specific time window, delayed administration is more effective than adoptive transfer at the time of transplantation. The model also suggests that the distribution of multiple small successive injections instead of a single large dose exerts the most protective effect. Overall, the use of a theoretical model to optimize adoptive transfer techniques has great potential to accelerate the identification of ideal treatment strategies for transplant patients.

Ellen Ellefsen, University of Colorado Boulder, erel0930@colorado.edu

Title: Efficiently Finding Steady States of Nonlocal Territorial Models in Ecology

Abstract: There are certain populations of animals that tend to move in social groups. We investigate territory development of these social groups by studying a system of non-local continuum equations. However, these equations pose both analytical and computational problems. Therefore, we perform a long-wave approximation to investigate a local approximation to this system. We take advantage of the structure of these local and non-local systems in order to find steady state solutions. We compare the steady states of the local and non-local model to see if the local model is a good enough approximation as we move towards future projects.

Room 112

Darryl Nester, Bluffton University, nesterd@bluffton.edu

Title: Compartmental Analysis, SIR models, and the Zombie Apocalypse

Abstract: Compartmental analysis is a useful tool for visualizing and numerically modelling certain kinds of dynamical systems-e.g., population growth, dilution (mixing) problems, or the spread of infectious diseases. A common example of the latter is the standard SIR (susceptible-infected-recovered) model, proposed by Kermack and McKendrick in 1927. We'll look at some

resources for analyzing such models, and explore some variations on the SIR model which attempt to adapt that model to the case of a zombie attack.

Roshini Gallage, Southern Illinois University, roshi@siu.edu

Title: Approximation of continuously distributed delay equation

Abstract: We present a theorem on the approximation of the solutions of delay differential equations with continuously distributed delay with solutions of delay differential equations with discrete delays. We present numerical simulations of the trajectories of discrete delay differential equations and the dependence of their behavior for various delay amounts. We further simulate continuously distributed delays by considering discrete approximation of the continuous distribution.

Room 114

Stephen Harnish, Bluffton University, harnishs@bluffton.edu

Title: Analyzing MD Simulations and Iterated Function Systems via 'Feasts and Famines' of Image Processing

Abstract: Molecular dynamics (MD) simulations numerically solve differential equations over finite time steps, and so represent discrete dynamical systems. Similarly, the recursively-defined, successive steps of an iterated function system (IFS) demonstrate a discretely unfolding dynamical system. We'll further connect these topics by showing how two basic image processing techniques akin to 'feasts' (dilations) and 'famines' (erosions) aid analyses of clustering and scaling factors within particular MD crystalline lattices as well as classical, IFS-generated fractals of Cantor, Koch and Sierpinski.

Stephane Lafortune, College of Charleston, lafortunes@cofc.edu

Title: Stability of Traveling Waves in a Model for a Thin Liquid Film Flow

Abstract: We consider a model for the flow of a thin liquid film down an inclined plane in the presence of a surfactant. The model is known to possess various families of traveling wave solutions. We use a combination of analytical and numerical methods to study the stability of the traveling waves. We show that for at least some of these waves the spectra of the linearization of the system about them are within the closed left-half complex plane.

Parallel Sessions, Saturday, September 21, 2019

Room 110

Chunhua Shan, University of Toledo, chunhua.shan@utoledo.edu

Tile: Periodic phenomena and driven mechanisms in transmission of West Nile virus with maturation time

Abstract: In this talk we will formulate a compartmental model with bird demographics and maturation time of mosquitoes during metamorphosis to study the impact of ambient temperature on the transmission and recurrence of disease. We show that avian birds serve as a reservoir of viruses, whilst maturation time affects disease transmission in sophisticated ways. It turns out that large maturation delay will lead to the extinction of mosquitoes and the disease; small maturation delay will stabilize the epidemic level of the disease; and intermediate maturation delay will cause sustainable oscillations of mosquito population, recurrence of diseases, and even

mixed-mode oscillation of diseases with an alternation between oscillations of distinct large and small amplitudes. With bifurcation theory, we prove that temperature can drive the oscillation of mosquito population, which leads recurrence of WNv through the incidence interaction between mosquitoes and hosts, while the biting and transmission process itself will not generate sustained oscillations. Our results provide a sound explanation for understanding interactions between vectors and hosts, and driven mechanisms of periodic phenomena in the transmission of WNv and other mosquito-borne diseases.

Scott Kaschner, Butler University, skaschne@butler.edu

Title: Superstable Manifolds and the Ising Model on Hierarchical Lattices

Abstract: The Ising Model uses graphs whose vertices represent atoms to model magnetization; associated to each graph is a partition function, whose zeros, called the Lee-Yang-Fisher (LYF) zeros, describe both the singularities of the model and actual physics (with large enough graphs). Bleher, Lyubich, and Roeder gave a rigorous description of the limiting distribution for the Lee-Yang zeros (a specific subset of the LYF zeros) of the Ising model on the diamond hierarchical lattice. This distribution can be described in terms of the dynamics of an explicit rational map in two variables. Among other things, it was shown that the stable manifold of an invariant circle, has regularity. I will prove that the stable manifold of is not real-analytic in a neighborhood of any point using techniques from complex geometry and complex dynamics. I will then relate this to the Lee-Yang and Lee-Yang-Fisher zeros and describe different lattices on which these results hold. Also, I will give examples of situations with similar assumptions in which the stable manifold is real-analytic.

Kyle Claassen, Rose-Hulman Institute of Technology, claassen@rose-hulman.edu

Title: Numerical Bifurcation and Spectral Stability of Wavetrains in Bidirectional Whitham Models

Abstract: We numerically explore the spectral stability of a class of periodic traveling wave solutions in several bidirectional Whitham models, which incorporate the full two-way dispersion relation of the incompressible Euler equations as well as a canonical shallow water nonlinearity. Via sixth-order pseudospectral methods, we examine the stability spectrum of large-amplitude waves generated by numerically continuing a branch of solutions that bifurcates from zero amplitude.

Naum I. Gershenzon, Wright State University, naum.gershenzon@wright.edu

Title: Application of sine-Gordon modulation equations for investigation of instability of frictional sliding

Abstract: Previously, we showed that the dynamics of frictional sliding of two bodies in contact could be described by the system of sine-Gorgon modulation equations derived from the Frenkel-Kontorova model. In this talk I will examine the necessary and sufficient conditions for instability of frictional sliding based this model and the rate-and-state frictional law. Two main findings follow from analysis. First, sliding instability may be developed in velocity-weakening (decrease of friction with increase of sliding velocity) as well as in velocity-strengthening (increase of friction with increase of sliding velocity) sliding, in contrast to a common assumption that only velocity-weakening sliding may lead to instability. Instability in velocity-strengthening case is possible if there is a gradient of shear to normal stress ratio. Second, the nucleation size is smaller in the presence of the gradient compared to the case of no gradient, which leads to an apparent conclusion that an earthquake is initiated in a place with maximal gradient. It is also shown that nucleation

size depends on the value of steady-state friction. Results support the point of view that nucleation size depends on the value of steady-state friction. Results support the point of view that analysis of sliding stability, as well as quantitative studies of earthquake dynamics, should include stress heterogeneity.

Andrei Prokhorov, University of Michigan, andreip@umich.edu

Title: Connection problem for Painlev tau functions

Abstract: Painlev equations are specific second order nonlinear differential equations. Their solutions have many applications in mathematics and physics and can be called special functions. Painlev transcendents admit Riemann-Hilbert representation which is the analog of contour integral representation for classical special functions. The relations between asymptotics of solutions in different directions on complex plane or near different singularities are called connection formulae for Painlev transcendents. They can be found after performing asymptotic analysis of corresponding Riemann-Hilbert problems. The Painlev equations can be interpreted as Hamiltonian systems. They describe the movement of particles in time-dependent potentials. The integrals of the Hamiltonians are called tau functions and they are of particular interests. Knowing the connection formulae for Painlev transcendents we can find the relations between asymptotics of tau function in different directions in complex plane or near different singularities, up to the constant term. Computation of this constant term is called connection problem for tau functions. It can be thought of as computation of regularized definite integral of Hamiltonian. The Hamiltonians of Painlev equations are quasihomogeneous functions. It means that they satisfy some differential identities, which relate tau functions to classical actions. Classical action is more convenient for asymptotic analysis which allows to reduce the connection problem for tau functions to the connection formulae for Painlev transcendents themselves.

Benjamin Akers, Air Force Institute of Technology, benjamin.Akers@afit.edu

Title: Dimension Breaking in Models for Interfacial Waves

Abstract: Dimension breaking as a numerical continuation procedure for computing three-dimensional traveling waves in models for interfacial flows will be presented. Dimension breaking continuations methods begin by linearizing a model equation about a planar, finite amplitude, traveling wave in search of a three-dimensional bifurcation. The nature of the linearized system will be discussed and the resulting problems will be solved in a sequence of model equations.

King-Yeung Lam, Ohio State University, lam.184@osu.edu

Title: Monotonicity and Global Dynamics of a Nonlocal Two-species Phytoplankton Model

Abstract: We investigate a nonlocal reaction-diffusion-advection system modeling the population dynamics of two competing phytoplankton species in a eutrophic environment, where nutrients are in abundance and the species are limited by light only for their metabolism. We first demonstrate that the system does not preserve the competitive order in the pointwise sense. Then we introduce a special cone $\mathcal{K}$ involving the cumulative distributions of the population densities, and a generalized notion of super- and subsolutions of the system in which the differential inequalities hold in the sense of the cone $\mathcal{K}$. A comparison principle is then established for such super- and subsolutions, which implies the monotonicity of the underlying semiflow with respect to the cone $\mathcal{K}$. As application, we study the global dynamics of the single species system and the competition system. The latter has implications for the evolution of movement for phytoplankton species.

Room 112

Ivan Sudakov, University of Dayton, isudakov1@udayton.edu

Title: Bifurcation analysis of species extinction in large competitive populations

Abstract: The extinction of species is a core process that affects the diversity of life on Earth. One way of investigating the causes and consequences of extinctions is to build conceptual ecological models, and to use the dynamical outcomes of such models to provide quantitative formalization of changes to Earth's biosphere. In this paper we propose and study a conceptual resource model that describes a sim- ple and easily understandable mechanism for resource competition, generalizes the well-known Huisman and Weissing model (1999), and takes into account species self-regulation, extinctions, and time dependence of resources. We use analytical investigations and numerical simulations to study the dynamics of our model under chaotic and periodic climate variability, and show that the stochas- tic dynamics of our model exhibit strong dependence on initial parameters. This model is apparently the first of its kind to include a feedback mechanism coupling climate and population dynamics. We also demonstrate that extinctions in our model are inevitable if an ecosystem has the maximal possible biodiversity and uses the maximal amount of resources. Our conceptual modeling provides the- oretical support for suggestions that non-linear processes were important during major extinction events in Earth history.

Son Van, Carnegie Mellon University, sonv@andrew.cmu.edu

Title: Optimal heat transfer in a box

Abstract: The problem of optimization of heat transfer is of both daily-life and industrial importance. Yet, not until recently, people started to tackle this problem with full mathematical rigor. In this talk, we will consider how to design a fluid flow in order to speed up heat transfer in a 2D square. The main idea is to re-scale the problem appropriately to get a degenerate advection-diffusion equation and use both PDE and probabilistic tools to study it.

Qiliang Wu, Ohio University, wuq@ohio.edu

Title: The Effect of Impurities on Stripes in Multi-Dimensional Extended Domains

Abstract: Periodic patterns are ubiquitous in nature and their manifestation is generically deformed and accompanied with defects, due to external forcing and/or impurity of the background. We study the effect of impurity on emerging periodic patterns in the 2D/3D Swift-Hohenberg equation. More specifically, we investigate spectrally stable periodic patterns with their corresponding linearized operators admitting essential spectrum continue up to the origin. These linearized operators are shown to be Fredholm on Kontradiev spaces-a special family of algebraically weighted Sobolev spaces. Exploiting a refined decaying structure of the linear flow and an implicit-function-theorem argument, we prove that the presence of localized impurity gives rise to deformed periodic patterns accommodating near-field deformation and far-field modulation.

Phillip Korman, University of Cincinnati, kormanp@ucmail.uc.edu

Title: Numerical computation of global solution curves using global parameters

Abstract: We discuss computations of the global bifurcation diagrams for the operator equation $Lu = \lambda f(u)$ by using global parameters, rather than the continuation in λ.

Peter Thomas, Case Western Reserve University, pjthomas@case.edu

Title: Two approaches to phase reduction for stochastic oscillators

Abstract: Nonlinear systems of ordinary differential equations with stable limit-cycle solutions often serve as models of autonomous oscillations, and reduction to 1D phase dynamics is an important tool for their analysis. The classical construction of oscillator phase breaks down for stochastic dynamical systems. I will discuss two alternative approaches to phase reduction for stochastic oscillators. One approach is based on a spectral decomposition of the generator of the Markov process describing the stochastic dynamics [Thomas and Lindner (2014) Phys. Rev. Lett.]. This "spectral asymptotic phase" applies not only to classical oscillators but also to noise-dependent oscillators including heteroclinic-type and quasicycle oscillators (e.g. planar Ornstein-Uhlenbeck processes) [Thomas and Lindner (2019) Phys. Rev. E.]. The alternative method is based on a system of Poincare sections satisfying a mean-return-time property [Schwabedal and Pikovsky (2013) Phys. Rev. Lett.], which we formulate as the solution of a partial differential equation [Cao, Lindner and Thomas (2019) arXiv].

Shusen Pu, Case Western Reserve University, sxp600@case.edu

Title: Stochastic Shielding for Stochastic Conductance-Based Neural Models under Current Clamp

Abstract: Exact Markov Chain (MC) algorithms exist for studying the stochastic opening and closing of ion channels in the nervous system, but are numerically expensive. As an alternative, faster algorithms based on Gaussian (Langevin) stochastic differential equation approximations have been proposed (Fox and Lu, 1994; Fox, 1997; Goldwyn and Shea-Brown, 2011; Linaro et al., 2011; Dangerfield et al., 2012; Orio and Soudry, 2012; Guler, 2013; Huang et al., 2013; Pezo et al., 2014). These algorithms differ in the number of independent white noise sources used to drive the channel state process, and the number of underlying channel states represented. Meanwhile, (Schmandt and Galan, 2012) introduced the stochastic shielding (SS) approximation as an efficient and accurate method for approximating the Markov process by identifying the fewest independent noise sources required for a given approximation accuracy. The talk will describe a natural 14-dimensional representation for Hodgkin and Huxley conductance dynamics, and show that it is equivalent to the original 4-dimensional HH model in the deterministic case. Moreover, we prove that several of the existing Langevin stochastic models are in fact pathwise equivalent. Our framework allows us to derive an analytic relation between independent noise sources (one for each directed edge in the channel state transition graph) and the variance of interspike intervals produced during suprathreshold spiking under current clamp.

Thomas Hill, University of Cincinnati, hill2ts@mail.uc.edu

Title: New method for dispersive estimates of second order Schrodinger Equation

Abstract: In this paper we will discuss a new method for obtaining various dispersive estimates for the second order Hamiltonians in one dimension. This includes the bound, an improvement for a bound, and a resonance case bound.

Chanaka Kottegoda, University of Toledo, chanaka.kottegoda@rockets.utoledo.edu

Title: Bifurcation Analysis of Predator-prey System with Holling Type IV Functional Response and Allee Effect

Abstract: In this talk I will show the existence of Bogdanov-Takens bifurcation of co-dimension 3 in the Predator - Prey system with Holling Type IV Functional Response and Allee Effect. Then I will show the necessary step to change the system to its normal form around a neighborhood of Bogdanov-Takens bifurcation of co-dimension 3 point in the parameter space.

Room 114

Niklas Manz, College of Wooster, nmanz@wooster.edu

Title: Visualizing dynamical systems with fire fronts

Abstract: Simple nonlinear table-top experiments are great media to explore spatiotemporal properties of dynamical systems. We are using a one-dimensional oil-candle system and two-dimensional matchstick arrays to experimentally investigate the behavior of excitable reaction-diffusion systems. In these setups, propagating fire fronts can display complex spatial dynamics by varying the oil viscosity and wick material of the candle system or the match type, arrangement, and slope of the matchstick array system.

Maria-Veronica Ciocanel, Ohio State University, ciocanel.1@osu.edu

Title: Insights for cellular transport from partial differential equations models

Abstract: Cells contain tubular structures called microtubules that ensure the dynamic transport and anchoring of various proteins and vesicles. In the development of many organisms (e.g. from egg to embryo), messenger RNA is transported along these microtubule roads and must accumulate (localize)

Peter Gordon, Kent State University

Title: Gelfand-type problem for turbulent jets

Abstract: In this talk I will discuss the model of auto-ignition (thermal explosion) of a free round reactive turbulent jet. This model falls into the general class of Gelfand-type problems and constitutes a boundary value problem for a certain semi-linear elliptic equation that depends on two parameters: α characterizing the flow rate and λ (Frank-Kamentskii parameter) characterizing the strength of the reaction. Similarly to the classical Gelfand problem, this equation admits a solution when the Frank-Kametskii parameter λ does not exceed some critical value $\lambda^*(\alpha)$ and admits no solutions for larger values of λ. I will discuss the sharp asymptotic behavior of the critical Frank-Kamenetskii parameter in the strong flow limit ($\alpha \gg 1$). We also provide a detailed description of the extremal solution (i.e., the solution corresponding to λ^*) in this regime. This is a joint work with Fedor Nazarov and Vitaly Moroz.

Laurence Robinson, Ohio Northern University, L-Robinson.1@onu.edu

Title: How Important is a Course in Differential Equations for Statisticians?

Abstract: Last year this question was posed to me by an undergraduate math major (with a statistics minor) at my University - a student who is now a graduate student in the M.S Statistics degree program at Miami University! My answer at the time was essentially "not much". However, just recently I have learned something new, involving the use of differential equations to obtain an important result in probability theory. In this lecture I will discuss this result.

Tom Cuchta, Fairmont State University, tcuchta@fairmontstate.edu

Title: Introduction to calculus on time scales with some applications

Abstract: Calculus on time scales is a relatively new branch of mathematics that both unifies and extend the traditional theories of differential equations, difference equations, and q-difference equations. In this talk, we will introduce the basic concepts of time scales calculus and explore some applications to population models.

Qingbo Huang, Wright State University, qingbo.huang@wright.edu

Title: Regularity theory for fully nonlinear elliptic equations with asymptotical approximate convexity

Abstract: In this talk, we will discuss our recent work on $W^{2,BMO}$ and $W^{2,p,}$ regularity for L^n-viscosity solutions of fully nonlinear elliptic equations with asymptotical approximate convexity.

Shuang Liu, Renmin University of China, liushuangnqkg@ruc.edu.cn

Title: On principal eigenvalues of second order elliptic operators with drift

Abstract: In this talk, we shall discuss some properties of principal eigenvalue for elliptic operators with drift. In particular, we will establish the monotonicity of the principal eigenvalue, as a function of the advection amplitude, for the elliptic operator with incompressible flow. This is a joint work with Prof. Yuan Lou.