Differential Equations & Applications
February 20th, 2018

The workshop will be held in room 318
Mathematical Sciences Building (MSB)
University of Central Florida, Orlando

Differential equations have played a prominent role in many disciplines of science and engineering. These applications include fundamental laws in physics and chemistry, modeling complex systems in biology and economics, and mechanical and electrical studies in engineering.

Theory of differential equations itself can be categorized into different types based on modeling states and factors incorporated. These include ordinary differential equations, partial differential equations, delay and functional differential equations, and stochastic differential equations.

The one-day workshop will focus on both theoretical results of modern differential equation theories and cutting-edge applications to ecology, epidemiology, public health and pattern information.

Organizers:

Andrew Nevai, University of Central Florida
Yuanwei Qi, University of Central Florida
Zhisheng Shuai, University of Central Florida

Invited Speakers:

Roy Choudhury
University of Central Florida

Xi Huo
University of Miami

Michael Li
University of Alberta, Canada

Andrew Nevai
University of Central Florida

Yuanwei Qi
University of Central Florida

Jiongmin Yong
University of Central Florida

Yuan Yuan
Memorial University of Newfoundland, Canada

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College of Sciences and *Department of Mathematics,* University of Central Florida

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Schedule:

9:00 am - 9:05 am	Welcoming remarks	
9:05 am - 9:50 am	**Jiongmin Yong**	"*Rabbits on grassland*"
10:00 am - 10:45 am	**Yuan Yuan**	"*A periodic disease transmission model with asymptomatic carriage and latency periods*"
11:00 am - 11:45 am	**Xi Huo**	"*Modelling antimicrobial de-escalation – when it is superior?*"
12:00 pm - 1:30 pm	Lunch Break	
1:30 pm - 2:15 pm	**Yuanwei Qi**	"*Traveling waves of Gray-Scott system in Turing pattern formation*"
2:30 pm -3:15 pm	**Roy Choudhury**	"*Competitive modes as reliable predictors of chaos versus hyperchaos and as geometric mappings accurately delimiting attractors*"
3:30 pm - 4:15 pm	**Michael Li**	"*Global dynamics of an infinite dimensional epidemic model with nonlocal state structures*"
4:30 pm - 5:15 pm	**Andrew Nevai**	"*Cats on the street*"
5:20 pm - 5:30 pm	Photo & concluding remarks	
6:30 pm	Dinner	

Acknowledgement:

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Abstracts

Rabbits on Grassland

Jiongmin Yong
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In this talk, a model is derived for a group of rabbits living on a grassland.

A Periodic Disease Transmission Model with Asymptomatic Carriage and Latency Periods

Yuan Yuan
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In this talk, we study the global dynamics of a periodic disease transmission model with two delays in incubation and asymptomatic carriage periods. We first derive the model system with a general nonlinear incidence rate function by stage-structure. Then we identify the basic reproduction ratio $\mathcal{R}_0$ for the model and present numerical algorithm to calculate it. We obtain the global attractivity of the disease-free state when $\mathcal{R}_0 < 1$ and discuss the disease persistence when $\mathcal{R}_0 > 1$. We also explore the coexistence of endemic state in the nonautonomous system and prove the uniqueness with constants coefficients. Numerical simulations are provided to present a case study regarding the meningococcal meningitis disease transmission and discuss the influence of carriers on $\mathcal{R}_0$.

This is a joint work with my PhD student Isam Al-Darabsah.

Modelling Antimicrobial De-Escalation – When It is Superior?

Xi Huo
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In our previous modelling work, “Benefits and unintended consequences of antimicrobial de-escalation: implications for stewardship programs”, we observed that de-escalation can be beneficial in terms of reducing strain transmissions under certain parameter settings. However, due to the complexity of the model, we were not able to mathematically characterize the impacts of these parameters on the model dynamics. Recently, we were able to simplify the models of antimicrobial de-escalation and continuation, and provide mathematical analysis to better explain and further understand our prior results. This talk will cover both the modelling work and our ongoing analysis.

Traveling Waves of Gray-Scott System in Turing Pattern Formation

Yuanwei Qi
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In this talk I shall present some recent results on rigorous proof of traveling fronts and traveling waves of Gray-Scott. Moreover, comparison with Auto-Catalytic chemical reactions system is also given.

Competitive Modes as Reliable Predictors of Chaos Versus Hyperchaos and as Geometric Mappings Accurately Delimiting Attractors

Roy Choudhury
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We consider real quadratic dynamics in the context of competitive modes, which allows us to view chaotic systems as ensembles of competing nonlinear oscillators. We find that the standard competitive mode conditions may in fact be interpreted and employed slightly more generally than has usually been done in recent investigations, with negative values of the squared mode frequencies in fact being admissible in chaotic regimes, provided that the competition among them persists. This is somewhat reminiscent of, but of course not directly correlated to, "stretching (along unstable manifolds) and folding (due to local volume dissipation)" on chaotic attractors. This new feature allows for the system variables to grow exponentially during time intervals when mode frequencies are imaginary and comparable, while oscillating at instants when the frequencies are real and locked in or entrained. In addition to an application of the method to chaotic attractors, we consider systems exhibiting hyperchaos and conclude that the latter exhibit three competitive modes rather than two for the former. Finally, in a novel twist, we reinterpret the components of the Competitive Modes analysis as simple geometric criteria to map out the spatial location and extent, as well as the rough general shape, of the system attractor for any parameter sets corresponding to chaos. The accuracy of this mapping adds further evidence to the growing body of recent work on the correctness and usefulness of competitive modes. In fact, it may be considered a strong a posteriori validation of the Competitive Modes conjectures and analysis.

Global Dynamics of an Infinite Dimensional Epidemic Model with Nonlocal State Structures

Michael Li
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We consider a state-structured epidemic model for infectious diseases which includes a nonlocal state structure, where the state is a measure of infectivity of infected individuals. The model gives rise to a system of nonlinear integro-differential equations with a nonlocal term. We establish the well-posedness and dissipativity of the associated the nonlinear semigroup. We establish an equivalent principal spectral condition between the linearized operator and the next-generation operator and show that the basic reproduction number $\mathcal{R}_0$ is a sharp threshold: if $\mathcal{R}_0 < 1$, the disease-free equilibrium is globally asymptotically stable, and if $\mathcal{R}_0 > 1$, the disease-free equilibrium is unstable and a unique endemic equilibrium is globally asymptotically stable.

Cats on the Street

Andrew Nevai
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We formulate and analyze a mathematical model for the population dynamics of feral cats. The model includes three categories: kittens, adult females and adult males. Kittens are born at a rate proportional to the adult female population. Adults compete for resources with both members of their own sex and members of the opposite sex. Feral cats are subject to various animal control measures including impounding, adoption, and euthanasia. The feral cat population also interacts with a fixed population of outdoor house cats, some of which experience abandonment. In some cases, the feral population becomes extinct while other parameter cases allow for the population to persist at a positive and globally asymptotically stable equilibrium. If only adult males can be abandoned then the model can exhibit up to two positive equilibrium points. When all three categories of cats can be abandoned then the model can exhibit up to four positive equilibrium points. The model can be extended to include the spatial movement of adult males and it can be used to describe the spread of feline leukemia within a feral cat population.

This work is a joint project with J. Sharpe.