2nd SIAM Knights Conference at UCF
(Webinar)

Eduardo Teixeira
Keynote speaker
University of Central Florida

Stanley Snelson
Keynote speaker
Florida Institute of Technology

• December, 4th 2020 •

Department of Mathematics, UCF

This is the second official activity of the SIAM Student Chapter at UCF.
All other talks in the Conference will be given by graduate and undergraduate students from UCF and other institutions.

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UNIVERSITY OF CENTRAL FLORIDA

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2nd SIAM Knights Conference at UCF

PROGRAM FOR FRIDAY DECEMBER 4TH, 2020

TIME*	EVENT	WITH
9:00 AM – 9:05 AM	Welcome to SIAM @ UCF	**Department Chair**
9:05 AM - 10:00 AM	"Degenerate diffusive processes and their intrinsic regularity theories"	**Eduardo Teixeira**, University of Central Florida
10:00 AM – 10:30 AM	"Piezoelectric and flexoelectric composites. Applications to biomaterials."	**David Guinovart**, University of Central Florida
10:30 AM – 11:00 AM	"High order approximation of the center manifold for the Henon-Heiles system"	**Emmanuel Fleurantin**, Florida Atlantic University
11:00 AM - 11:30 AM	"Online optimization with Barzilai-Borwein quasi-Newton method."	**Iyanuoluwa Emiola**, University of Central Florida
11:30 AM – 12:00 PM	"The Impact of travel restrictions on the spread of infectious diseases"	**Seoyun Choe**, University of Central Florida
12:00 PM – 12:30 PM	"Algebraic and combinatorial approaches for counting cycles arising in population biology"	**Brian Chau,** University of Central Florida
12:30 PM – 2:00 PM	**BREAK**	
2:00 PM - 3:00 PM	"Mathematical approaches to kinetic theory: history and recent progress"	**Stanley Snelson**, Florida Institute of Technology
3:00 PM – 3:30 PM	"Homogenization of periodic porous ceramics for energy-harvesting applications"	**Rogelio Caballero**, IIMAS-UNAM (Mexico)
3:30 PM – 4:00 PM	"Wavelets for Partial Differential Equations"	**Ratikanta Behera,** University of Central Florida
4:00 PM – 4:30 PM	"Competition and cooperation on predation"	**Srijana Ghimire**, University of Louisiana at Lafayette
4:30 PM – 5:00 PM	"Mathematical model of the spread of HSV Type-2 in heterosexual relations with and without the usage of condoms in a closed college population"	**Jacob Braun**, University of Central Florida
5:00 PM – 5:30 PM	"Periodic, quasiperiodic, and blow-up regimes in a nonlinear Mathieu equation with distributed delay"	**Ranses Alfonso**, University of Central Florida
5:30 PM – 5:35 PM	Closing Event	**Organizing Committee**

*Eastern Time

ZOOM Meeting: https://ucf.zoom.us/j/93158561166

Degenerate diffusive processes and their intrinsic regularity theories

Eduardo Teixeira, University of Central Florida.
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Diffusion refers to a natural trend of equilibrium, balance, or spread of quantities in physical systems and models. Smoothing effects are among the most prominent features of the theory with a broad array of applications. In this talk I will describe the rich connection between the physical notion of diffusion and mathematical regularity estimates. I will be particularly interested in phenomena involving diffusion collapse and how these affect intrinsic regularity theories of models.

Computation of effective properties of smart composite materials

David Guinovart, University of Central Florida.
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The work is focuses on the study of composite materials and a method of deriving the effective mechanical and electrical properties. In order to achieve the objectives, the equilibrium problem in curvilinear three-dimensional composite structures with generalized periodicity is considered. The problem is subject to various combinations of the physical properties like elasticity, piezoelectricity and flexoelectricity with perfect and imperfect contacts at the interfaces. The two-scale asymptotic homogenization method (AHM) is used to derive the expressions for the local problems and the effective coefficients. Moreover, we present a methodology to find the analytical solutions of the local problems for different cases of symmetry of the elements of the composite material considering perfect and imperfect contacts. The general expressions for the homogenized problem are derived for all the cases considered. To validate the model, some numerical examples are presented, and the results are compared with the data obtained by the finite elements method (FEM). Applications to bio-composites and engineering are proposed.

High order approximation of the center manifold for the Henon-Heiles system

Emmanuel Fleurantin, Florida Atlantic University.
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In this talk, we will discuss a general method for computing center manifolds for Hamiltonian systems in the finite-dimensional case. We will derive the homological equation and compute the center manifold using the graph transform method for the Henon-Heiles system. We will also briefly discuss next steps in the validation process.

Online optimization with Barzilai-Borwein quasi-Newton method.

Iyanuoluwa Emiola, University of Central Florida.
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This paper considers the online case for the Barzilai-Borwein quasi-Newton method and presents a regret analysis. To solve online convex optimization problems, sequential decisions are made at each time-step using some algorithm of choice. We use a greedy online gradient algorithm based on Barzilai-Borwein (BB) step sizes and show that the regret obtained from our algorithm is sublinear in time and that the average regret approaches zero. Analysis is presented for the two forms of the Barzilai-Borwein step sizes.

The Impact of travel restrictions on the spread of infectious diseases

Seoyun Choe, University of Central Florida.
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In amid of COVID-19 and other infectious disease pandemics, governments might pose various travel restriction policies. A new multi-patch epidemiological model has been proposed to investigate the impact of travel restrictions (e.g., lockdown) on the spread of infectious diseases in a heterogeneous environment. The basic reproduction number of the model has been derived, which has proven to be sharply bounded and monotone with respect to the travel restriction measure. Numerical simulations illustrate that the dependence of the final attack ratio (the final disease size) on the travel restriction measure could be complex – monotone increases, monotone decreases, and non-monotone changes have all been observed – further studies incorporating disease surveillance data are necessary and essential.

Algebraic and combinatorial approaches for counting cycles arising in population biology

Brian Chau, University of Central Florida.
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The literature contains many algebraic and combinatorial approaches for deriving the net reproduction number and generalized target reproduction numbers from digraphs and associated matrices. These numbers describe the growth or decline of a population and are often used for population management analysis when used as a measure of the effort needed to control a population. They may also provide some biological insight in some forms. The Cycle Union approach by Lewis et al. (2019) does not provide a biologically intuitive form of these numbers but does have the benefit of being a computationally simple approach. It requires finding, categorizing, and counting the permutations of disjoint cycles, or cycles unions. Finding and categorizing all cycle unions is a simple, but tedious task prone to errors without a proper counting strategy. We developed cycle union counting patterns for Leslie Matrices, Lefkovitch Matrices, Sub-Diagonal Lower Triangle Transition Matrices, and Lower Triangle Transition Matrices to serve as a foundation for future work. Presented are counting patterns targeting individual arcs and the closed-form summations of the cycle unions.

Mathematical approaches to kinetic theory: history and recent progress

Stanley Snelson, Florida Institute of Technology.
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Kinetic theory seeks to understand the physical properties of matter by studying statistical averages of its constituent particles. Mathematically, this leads to a differential equation for the particle density function (i.e. the density of particles at time t, location x, and velocity v). This talk will focus on two classical kinetic differential equations: the Boltzmann equation (1872) which models diffuse gases, and the Landau equation (1936) which models plasmas. Despite their long history, these equations have proven difficult to understand mathematically, and the question of global existence vs. breakdown remains open (in the general case) for both equations. I will give an overview of recent progress on these equations, focusing especially on the program of conditional regularity, which gives physically meaningful conditions under which the solution can be extended past a given time. Finally, I will discuss some promising directions for future research.

Homogenization of periodic porous ceramics for energy-harvesting applications

Rogelio Caballero, IIMAS-UNAM (Mexico).
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We consider the elliptical tensor-weighted boundary value problem with rapidly oscillating coefficients that describes the linear thermo-piezoelectric properties of a porous ceramic matrix with transversely isotropic crystal symmetry. We apply the Asymptotic Homogenization Method (AHM) to obtain the local problems and, ultimately, the effective coefficients of such class of materials. The local problems with free boundary conditions are solved via a Finite Element Method (FEM) whose implementation is discussed in detail since the large difference in orders of magnitude of the coefficients causes the algorithms to diverge in some cases. The results via FEM when compared with analytical ones, show excellent agreement. We also transform the effective coefficients to the Strain-Charge-Entropy formulation of the constitutive relations in order to compute the piezoelectric and pyroelectric figures of merit (FoMs) of the porous ceramic. We compare our results with some recent experimental findings that prove those materials to be good candidates for energy-harvesting applications.

Wavelets for partial differential equations

Ratikanta Behera, University of Central Florida.
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Mathematical modeling of problems in science and engineering typically involves solving partial differential equations. However, this becomes particularly challenging for problems having localized structures or sharp transitions. The numerical solution of such problems on uniform grids is impractical since high-resolution computations are required only in regions where sharp transitions occur. An adaptive wavelet collocation method provides a robust method for controlling spatial grid adaptation - fine grid spacing in regions where a solution varies greatly (i.e., near steep gradients, or near-singularities) and a much coarser grid where the solution goes slowly. In this talk, we will discuss an adaptive wavelet collocation method with the solution of a linear advection equation and a non-divergent barotropic vorticity equation on the sphere.

Competition and cooperation on predation

Srijana Ghimire, University of Louisiana at Lafayette.
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We propose a predator-prey model which takes into consideration cooperation among predators. Local and global dynamics are studied for the model system. Our study demonstrates that cooperative predation could make some significant changes on the model outcomes. The cooperative predation may (1) help a predator to survive in a severe condition; (2) break competitive exclusion principle and establish co-existence of different predators; (3) destabilize a positive equilibrium and induce a Hopf bifurcation; and (4) create a bistable balance between predator-free equilibrium and a positive equilibrium (or a limit cycle).

Mathematical model of the spread of HSV Type-2 in heterosexual relations with and without the usage of condoms in a closed college population

Jacob Braun, University of Central Florida.
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In the total population, there are almost two times as many women who have Herpes Simplex Type-2 as men. Additionally, Herpes Simplex Type-2 does not have a known cure. The goal of the model is to show how condom usage affects women's chances of receiving the virus in the hope of being able to reduce the number of women infected. This paper uses mathematical modeling to show the spread of Herpes Simplex type-2 with and without the usage of condoms in a college population. The model uses four differential equations to calculate the data for the simulation. The average age of the individual is 21, to represent the age of someone in college. In the end, the model demonstrates that condoms offer significant protection to women from the virus. The reproduction number of the virus and the effective reproduction numbers are found to help better explain the model.

Periodic, quasiperiodic, and blow-up regimes in a nonlinear Mathieu equation with distributed delay

Ranses Alfonso, University of Central Florida
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The dynamics of a delayed nonlinear Mathieu equation:

$$\ddot{x} + (\delta + \epsilon\alpha\cos t)\,x + \epsilon\gamma x^3 = \epsilon\beta\int_{-\infty}^{t} x\,(\tau)\,\xi e^{-\xi(t-\tau)}d\tau$$

is investigated in the neighborhood of $\delta = 1/4$. Three different phenomena are combined in this system: integral delay, cubic nonlinearity and 2:1 parametric resonance. The averaging method is used to obtain a slow flow that is analyzed for stability and bifurcations. In particular, we investigate bifurcations of the fixed points of the first slow flow, which correspond to periodic solutions of the full system. When these fixed points go unstable, depending on the type of bifurcation, one may have: a. a periodic orbit born in the slow flow via a Hopf bifurcation, and corresponding to quasiperiodic behavior of the full system; or b. transition to amplitude death, corresponding to the trivial fixed point of the slow flow; or c. blow-up if no stable local attractors exist in the slow flow. The analytical results are supported by numerical simulations of the original unaveraged system, except in blow-up regimes where the averaging assumptions fail.