FLORIDA STATE UNIVERSITY

Department of Mathematics

Title and Abstracts

Second Joint Alabama-Florida Conference on Differential Equations, Dynamical Systems and Applications

May 18-19, 2024

Plenary Talks

Andrea Bertozzi **University of California at Los-Angeles**

Abstract: To be announced.

Percy Deift **Courant Institute, New York University**

On the open Toda chain with external forcing

Abstract: The speaker will consider the open Toda chain with external forcing. When the forcing stretches the chain, we show that the system is completely integrable. The behavior of the system when the forcing compresses the chain, is a very intriguing open question.
This is joint work with L-C. Li, H.Spohn , C.Tomei and T. Trogdon.

Alexander Kiselev **Duke University**

The flow of polynomial roots under differentiation

Abstract: The question of how polynomial roots move under differentiation is classical. Contributions to this subject have been made by Gauss, Lucas, Marcel Riesz, Polya and many others. In 2018, Stefan Steinerberger derived formally a PDE that should describe the dynamics of polynomial roots under differentiation in certain situations. The PDE in question is of hydrodynamic type and bears a striking resemblance to the models used in mathematical biology to describe collective behavior and flocking of various species- such as fish, birds or ants. I will discuss joint work with Changhui Tan in which we establish global regularity of Steinerberger's equation and make a rigorous connection between its solutions and evolution of roots under differentiation for a class of trigonometric polynomials.

Nancy Rodriguez | **University of Colorado at Boulder**

A journey in the use of mathematical models to gain insight into ecological and sociological phenomena

Abstract: While mathematical models have classically been used in the study of physics and engineering, recently, they have become important tools in other fields such as biology, ecology, and sociology. In this talk, I will discuss the use of partial differential equations and dynamical systems to shed light on social and ecological phenomena. In the first part of this talk, we will focus on an Ecological application. For an efficient wildlife management plan, we must understand (1) why animals move as they do and (2) what movement strategies are robust. I will discuss how reaction-advection-diffusion models can help us shed light into these two issues. The second part of the talk will focus on social applications. I will present a few models in the study of gentrification, urban crime, and protesting activity and discuss how theoretical and numerical analysis have provided intuition into these different social phenomena. Moreover, I will also point out the many benefits of utilizing a mathematical framework when data is not available.

Gigliola Staffilani | **Massachusetts Institute of Technology**

Some recent developments in wave turbulence theory

Abstract: In this talk I will use the 2d periodic cubic defocusing nonlinear Schrodinger (NLS) equation to discuss the evolution of the energy spectrum of this system. Using Bourgain's idea of gathering information on the spectrum via the analysis of the long type growth of high Sobolev norms, I will analyze how the periodicity of the domain influence this growth.

Invited Talks

Abba Ramadan **University of Alabama**

Curvature-Driven Complexity in the Defocusing Parametric

Abstract: Nonlinear Schrodinger System The parametric nonlinear Schrodinger equation models a variety of parametrically forced and damped dispersive waves. For the defocusing regime, we derive a normal velocity for the evolution of curved dark-soliton fronts that represent a π-phase shift across a thin interface. We establish a simple mechanism through which the parametric term transitions the normal velocity evolution from a curvature-driven flow to motion against curvature regularized by surface diffusion of curvature. In the former case, interfacial length shrinks, while in the latter case interface length generically grows until self-intersection followed by a transition to complex motion.
This is a joint work with Keith Promislow.

Alexandra Smirnova **Georgia State University**

Theoretical and Numerical Study of Case Reporting Rate with Application to Epidemiology

Abstract: A clear understanding of actual infection rate is imperative for control and prevention. In particular, it helps in formulating effective vaccination strategies and in assessing the level of herd immunity required to contain the virus. In this project, we conduct theoretical and numerical study of a novel optimization procedure aimed at stable estimation of incidence reporting rate and time-dependent effective reproduction number from real data on new incidence cases, daily new deaths, and vaccination percentages. The iteratively regularized optimization algorithm can be applied to a broad class of data fitting problems constrained by various biological models, where one has to account for under-reporting of cases. To that end, general nonlinear observation operators in real Hilbert spaces are considered in the proposed convergence analysis.
To illustrate theoretical findings, numerical simulations with $S V I_u I_v R D$ compartmental model and real data for Delta variant of COVID-19 pandemic in different states of the US are conducted.

Alim Sukhtayev

Miami University, Ohio

Renormalized oscillation theory for Hamiltonian pencils

Abstract: Working with a general class of linear Hamiltonian systems with nonlinear dependence on the spectral parameter, we show that renormalized oscillation results can be obtained in a natural way through consideration of the Maslov index associated with appropriately chosen paths of Lagrangian subspaces. By reduction to a generalized nonlinear eigenvalue problem, we apply our results to a class of models such as magneto-hydrodynamics systems and the Saint-Venant equations.

Anh Khoa Vo

Florida A&M University

Convexification and experimental data for a 3D inverse scattering problem with the moving point source

Abstract: Reconstruction of physical properties of a medium from boundary measurements is one of the substantially challenging inverse scattering problems. In this talk, we present a convexification method to find the dielectric constant as an unknown coefficient of a three-dimensional Helmholtz equation for the case when the backscattering data are generated by a point source running along an interval of a straight line and the wavenumber is fixed. Using a special Fourier basis, the method of this work strongly relies on a new derivation of a boundary value problem for a system of coupled quasilinear elliptic equations. We then introduce a cost functional in the partial finite difference, weighted by a suitable Carleman weight function. This numerical setting allows us to verify the performance of the method using experimental data in which the spatial discretization is fixed.
The experimental data were collected using a microwave scattering facility at The University of North Carolina at Charlotte.

Anna Ghazaryan

Miami University, Ohio

On the stability of fronts in the diffusive Rosenzweig-MacArthur model

Abstract: We consider a diffusive Rosenzweig-MacArthur predator-prey model in the situation when the prey diffuses at the rate much smaller than that of the predator. In a certain parameter regime, the existence of fronts in the system is known: the underlying dynamical system in a singular limit is reduced to a scalar Fisher-KPP equation and the fronts supported by the full system are small perturbations of the Fisher-KPP fronts. The existence proof is based on application of the Geometric Singular Perturbation Theory with respect to two small parameters. This paper is focused on the stability of the fronts. We analyze the stability by means of energy estimates, exponential dichotomies, the Evans function calculation, and a technique that involves constructing the unstable augmented.
This is joint work with Anna Ghazaryan, Stephane Lafortune, Yuri Latushkin, and Vahagn Manukian.

Atanas Stefanov

University of Alabama at Birmingham

Solitary waves for the Whitham equation

Abstract: Recently, two different proofs for large and intermediate-size solitary waves of the non-locally dispersive Whitham equation have been presented, using either global bifurcation theory or the limit of waves of large period. We pursue a different approach by maximizing directly the dispersive part of the energy functional, while keeping the remaining nonlinear terms fixed with an Orlicz-space constraint. The constructed solutions are bell-shaped in the sense that they are even, one-sided monotone, and attain their maximum at the origin. The method is not limited to small waves: a family of solutions is obtained, along which the dispersive energy is continuous and increasing. In general, our construction admits more than one solution for each energy level, and waves with the same energy level may have different heights. Although a transformation in the construction hinders us from concluding the family with an extreme wave, we give a quantitative proof that the set reaches 'large' or 'intermediate-sized' waves.
Joint work with M. Arnesen and M. Ehrnstrom, NTNU.

Gabriela Jaramillo — **University of Houston**

Existence of Spiral Waves in Oscillatory Media with Nonlocal Coupling

Abstract: We prove existence of spiral waves in oscillatory media with nonlocal coupling. Our starting point is a nonlocal complex Ginzburg-Landau (cGL) equation, rigorously derived as an amplitude equation for integro-differential equations undergoing a Hopf bifurcation. Because this reduced equation includes higher order terms that are usually ignored in a formal derivation of the cGL, the solutions we find also correspond to solutions of the original nonlocal system. To prove existence of these patterns we use perturbation methods together with the implicit function theorem. Within appropriate parameter regions, we find that spiral wave patterns have wavenumbers, κ, with expansion $\kappa \sim C \rme^{-a/\eps}$, where a is a positive constant, $\eps$ is the small bifurcation parameter, and the constant C depends on the strength and spread of the nonlocal coupling.

Gong Chen — **Georgia Institute of Technology**

Recovery of the nonlinearity from the modified scattering map

Abstract: We consider the problem of recovering the nonlinearity in a nonlinear Schrödinger equation from scattering data, a problem for which there is a relatively large literature. We consider a new situation in which the equation does not admit standard scattering, but instead features the modified scattering behavior with logarithmic phase correction. We prove that even in this case, the modified scattering data suffices to determine the unknown nonlinearity.

Oleg Asipchuck — **Florida International University**

Existence and non-existence of ground state solutions for magnetic NLS

Abstract: In my talk, I will present our recent result on the existence and stability of ground state solutions for L^2-critical magnetic nonlinear Schrödinger equations for a class of unbounded electromagnetic potentials. Also, I will provide non-existence results by constructing a sequence of vortex-type functions in the setting of RNLS with an anisotropic harmonic potential.

Graham Cox

Memorial University in St. John's, Newfoundland, Canada

Geometry and topology of spectral minimal partitions

Abstract: A minimal partition is a decomposition of a manifold into disjoint sets that minimizes a certain energy functional. In the bipartite case minimal partitions are closely related to eigenfunctions of the Laplacian, but in the non-bipartite case they are difficult to classify, even for simple domains like the square or the disk. I will present new results that say a partition that minimizes energy locally is in fact a global minimum (in the bipartite case) and a minimum within a certain topological class of partitions in the non-bipartite case. I will also explain how to construct energy-decreasing deformations of a non-minimal partition, giving insight into the geometric structure of the true minimum.
This is joint work with Gregory Berkolaiko, Yaiza Canzani, Peter Kuchment and Jeremy Marzuola.

Hewan Shemtaga

Auburn University

Global existence and asymptotic behavior of chemotaxis models on a compact metric graph

Abstract: Chemotaxis phenomena governs the directed movement of micro- organisms in response to chemical stimuli. We investigate a pair of logistic type Keller–Segel systems of reaction-advection-diffusion equations modeling chemotaxis on networks. The distinction between the two systems is driven by the rate of diffusion of chemo-attractant. We prove the global existence of classical solution subject to Neumann-Kirchhoff vertex conditions without any conditions on chemotaxis sensitivity. In addition, we show that solutions with a non-negative and non-zero initial function converge to a globally stable constant solution for relatively small chemotaxis sensitivity. However, as chemotaxis sensitivity increase, we prove the constant solution loses stability and there exist other non-constant steady states bifurcating from the constant solution.
This is a joint work with my advisors Dr. Wenxian Shen (Auburn) and Dr. Selim Sukhtaiev (Auburn).

Igor Kukavica **University of Southern California**

Local existence for a fluid-structure interaction problem

Abstract: We address a system of equations modeling an incompressible fluid interacting with an elastic body. We consider the local well-posedness of solutions in spaces of minimal regularity.
The results are joint with Linfeng Li and Amjad Tuffaha.

Iryna Petrenko **Florida International University**

NLS with higher order dispersion

Abstract: We review a nonlinear Schrödinger equation, including a higher order dispersion instead of the standard Laplacian. We discuss the known local and global well-posedness results and extend them for the equation with a low power nonlinearity as well as with combined nonlinearities.

Maja Taskovic **Emory University**

On the well-posedness of the Boltzmann hierarchy

Abstract: The Boltzmann hierarchy is an infinite system of linear coupled equations that are instrumental for the rigorous derivation of the Boltzmann equation from many particles. In this talk we will present a global in time well-posedness result for the Boltzmann hierarchy. Existence of global in time mild will be shown for admissible initial data. The proof is constructive, and employs known global in time solutions to the Boltzmann equation via a Hewitt-Savage type theorem. Uniqueness of the mild solutions is obtained by combining a combinatorial technique known as the Klainerman-Machedon board game argument together with an L^∞-based estimate.
The talk is based on a joint work with I. Ampatzoglou, J.K. Miller and N. Pavlović.

Martin Bauer **Florida State University**

Geometric Analysis of the Generalized Surface Quasi-Geostrophic Equations

Abstract: In this talk we are interested in the geometry of the beta-SQG equations, a family of PDEs in two dimensions which interpolate between the Euler equations of ideal hydrodynamics and the inviscid surface quasi-geostrophic equation. It has been recently observed that these equations can be derived as Euler-Arnold equations on the group of symplectiomorphisms and In this talk we will analyze the properties of this geometric interpretation. In the first part we will study the induced geodesic distance, which is related to the variational formulation of the PDE and in the second part we will show precisely when the corresponding Riemannian exponential map is non-linear Fredholm of index 0. Finally, we will further illustrate this by examining the distribution of conjugate points via a Morse theoretic approach. This talk is based on work with Philipp Harms, Patrick Heslin, Gerard Misiołek and Stephen C. Preston.

Miguel A. Bandres **University of Central Florida, College of Optics and Photonics**

Light Meets Math: From Modeling Differential Equations through Laser Resonators to Branched Flow of Light

Abstract: Optics offers an unparalleled platform for exploring wave dynamics in unprecedented ways. In this talk, I will discuss the experimental observation of two novel wave phenomena observed through light. Initially, by exploring the isomorphism between stable laser resonators and quadratic Hamiltonians, we design a laser resonator that mirrors a quantum anisotropic harmonic oscillator with a 2:1 frequency ratio. This novel approach allows us to experimentally observe the Boyer-Wolf Gaussian modes for the first time in any physical system. Second, we will present how, through optics, we can experimentally study the universal wave phenomenon of Branched Flow, in which waves form channels of enhanced intensity that keep dividing as they propagate, forming a beautiful pattern resembling the branches of a tree.

Nick Moore **Colgate University**

Reversals of the large-scale circulation in thermal convection

Abstract: The large-scale circulation (LSC) associated with thermal convection is known to spontaneously reverse direction. In the atmosphere, reversals can result in a sudden change in wind direction, while in the liquid core, reversals may play a role in magnetic dipole shifts. We examine LSC reversals within the context of thermal convection in an annular domain. Through comparison with direct numerical simulations, we show that a low-dimensional dynamical system derived systematically from Galerkin truncation of the governing equations accurately describes a sequence of parameter bifurcations, including the onset of circulatory flow, the appearance of chaotic LSC reversals, and finally a high-Rayleigh-number state of periodic LSC reversals with small-scale turbulence. When cast in terms of the fluid's angular momentum and center of mass, the model reveals equivalence to a pendulum system with driving term that raises the center of mass above the fulcrum. It is the competition between driving, restoring, and damping that leads to the range of convective states. This physical picture yields accurate predictions for the frequency of regular LSC reversals in the high Rayleigh-number limit and offers a transparent mechanism for reversals.

Sara Pollock **University of Florida**

Filtered Anderson Acceleration for Numerical PDE

Abstract: The efficient solution of systems of nonlinear equations is an important tool for the modeling of physical phenomena. In this talk, we will discuss a powerful and low-cost method for accelerating the convergence of fixed-point iterations, known as Anderson acceleration (AA). First developed in the 1960s in the context of integral equations, this method has become increasingly popular due to its efficacy on a wide range of problems, including discretized nonlinear PDE. AA requires the storage of a relatively small number of solution and update vectors, and the solution of an optimization problem that is generally posed as least-squares. On any given problem, how successful it is depends on the details of its implementation. We will introduce the algorithm and an efficient filtering strategy to improve the numerical stability and performance of AA.

Solomon Manukure — **Florida A & M University**

Some exact solutions associated with a modified (2+1) dimensional nonlinear equation with variable coefficients

Abstract: Research in mathematical physics has long been centered on nonlinear integrable systems. In recent times, there has been a heightened interest in integrable equations involving variable coefficients. While such equations are more complex, they provide a more precise depiction of various real-life physical phenomena, particularly when considering the diverse nature of wave propagation media.

In this presentation, we will discuss some exact solutions associated with a modified (2+1)-dimensional nonlinear equation with variable coefficients. The discussion will specifically revolve around exact solutions such as solitons, lump solutions, rogue waves, breather solutions, and interaction solutions, some of which have been observed in oceanic phenomena.

Stephen Preston — **City University of New York**

Liouville comparison theory for blowup of Euler-Arnold equations

Abstract: We describe a new method for proving blowup of certain Euler-Arnold equations, partial differential equations which represent geodesics on groups of diffeomorphisms under right-invariant metrics. It is based on using momentum conservation to treat the equation as a first-order ODE on a Banach space, then using proving that solutions breakdown based on a comparison theorem using the known exact solution of the classical Liouville equation. Applications are given for the right-invariant H^2 Sobolev metric on the group of diffeomorphisms of R^n, where we show that solutions can break down in finite time if n≥3.

Tim Faver **Kennesaw State University**

Periodic traveling waves in dimer Fermi-Pasta-Ulam Tsingou lattices without symmetry

Abstract: We prove the existence of small-amplitude periodic traveling waves in dimer Fermi-Pasta-Ulam-Tsingou (FPUT) lattices without assumptions of physical symmetry. Such lattices are infinite, one-dimensional chains of coupled harmonic oscillators in which the oscillator masses and/or the coupling potentials can alternate. Previously, periodic traveling waves were constructed in a variety of limiting regimes for the symmetric mass and spring dimers, in which only one kind of material data alternates. These results remove the symmetry assumptions by exploiting the gradient structure and translation invariance of the traveling wave problem, which together eliminate certain solvability conditions that symmetry would otherwise manage.

Wojtek Ozanski **Florida State University**

Instantaneous gap loss of Sobolev regularity for the 2D incompressible Euler equations.

Abstract: We will discuss local well-posedness and ill-posedness results of some active scalar equations, including 2D incompressible Euler equations and the SQG equation. We will discuss how one can obtain instantaneous growth of solutions using a perturbation of a steady initial data as well as making use of unboundedness of the Riesz transform in L^∞. We will then discuss the first result of an instantaneous gap loss of Sobolev regularity for 2D Euler. Namely, we will describe a construction of initial vorticity for the 2D Euler equations that belongs to the Sobolev space H^β, $\beta \in (0,1)$ which gives rise to a unique global-in-time solution that instantaneously leaves not only H^β, but also $H^{\beta'}$ for every $\beta' >(2-\beta)\beta /(2-\beta^2)$. This is joint work with Diego Cordoba and Luis Martinez-Zoroa.

Malbor Asllani **Florida State University**

The formation theory of chimera patterns

Abstract: Chimera states, marked by the coexistence of synchronized and unsynchronized phases in oscillator networks, have intrigued researchers with their complex patterns. Despite progress, the full understanding of their emergence remains challenging. This study introduces a novel method to investigate chimera states in terms of phase and amplitude, employing weakly nonlinear analysis and the spectral properties of complex networks. We find that chimeras result from the interplay between local and global dynamics at different time scales. Our approach, validated through simulations and analyses of empirical networks, advances knowledge of coupled oscillator dynamics. The study particularly emphasizes how the randomness of network topology influences the emergence of chimera patterns, underscoring the critical role of network structure.

Rachidi Salako **University of Nevada Las Vegas**

Dynamics of classical solutions to a diffusive epidemic model with varying population demographics

Abstract. We study the asymptotic dynamics of solutions to a diffusive epidemic model with varying population dynamics. The large-time behavior of solutions is completely described in spatially homogeneous environments. When the environment is spatially heterogeneous, it is shown that the magnitude of the ratio of the susceptible population diffusion rate over the infected population diffusion rate plays an important role on the structure of the endemic equilibrium (EE) solutions. Results on the asymptotic profiles of the EEs for small population diffusion rates will also be discussed.
Our results shed some light on the differences on disease predictions for constant total population size models versus varying population size models.

Mark Sussman

Florida State University

Coupling the level set method to moments and particles for computing solutions to N-phase multiphase flows with phase change.

Abstract: A suite of numerical methods, all of which are (1) volume preserving, (2) capable of running on large heterogeneous computing machines, (3) allow for complex topology, (4) represent deforming boundaries sharply, and (5) are discretized on a dynamic block structured hierarchical grid, are compared and contrast on benchmark N-phase flow problems with/without phase change.

The benchmark problems are motivated by materials processing and zero-gravity cryogenic fuel tank applications.

Troy Johnson

University of Colorado

Approximating rational solutions to partial differential equations using Malmquist–Takenaka rational functions

Abstract: Approximating rational solutions to partial differential equations is often difficult using traditional numerical methods such as spectral Fourier methods, due to slow (algebraic) decay of the functions. This talk will introduce the Malmquist-Takenaka (MT) functions as a suitable basis for representing rational functions. The MT functions are set of orthogonal rational functions that, importantly, can be related to the discrete Fourier transform and whose coefficients can be computed via a modified fast Fourier transform.

Many examples illustrating the effectiveness of this approach will be given.

05:20-06:20	Room CGE	Poster Sessions at the Center for Global Engagement

Poster Session: Saturday: May 18, 2024

Sima Moshafi **Georgia State University**

Cake buildup and its influence on flow and transport within pleated membrane filters

Abstract: Pleated membrane filters are essential in various industries due to their greater surface area-to-volume ratio compared to flat filters. This research introduces a mathematical model to understand fouling processes, especially focusing on cake formation and flow dynamics in pleated membrane filters. Our three-dimensional model views the pleated region of the membrane as comprising four separate sub-regions: the plus support layer, the cake layer, the membrane layer, and the minus support layer. We use Darcy's law, the Stokes equation, and the advection-diffusion equation to simulate flow and movement within these pleated membrane areas and the entire filter cartridge. To manage the complexity of both the model and the filter's structure, we apply asymptotic analysis methods, taking into account the small aspect ratios of the filter cartridge and pleated membrane. The findings from this study provide critical insights for enhancing pleat packing density and overall filter efficacy, while keeping particle concentrations within set limits.

Faharudeen Alhassan **Georgia State University**

Investigating the impact of gas bubbles in flow streams and porous media.

Abstract: In the study of multi-phase chemical and electrochemical reaction systems, fluid streams containing dissolved gas or gas bubbles are directed alongside a thin flat sheet of porous medium characterized by varying surface energies. Within this setup, crucial reactions take place at the interface between the porous material and the fluid. The degree of surface wetting significantly influences the reaction rates, emphasizing the importance of complete wetting of the porous material by the liquid phase. However, the presence of gas bubbles introduces complexities, as their dynamics can diminish the surface area available for contact with the liquid phase. This research aims to comprehensively investigate the dynamics of bubble interactions and dissolved gas within the porous material, with the goal of optimizing processes and designs.

Lawan Wijayasooriya
Georgia State University
Polyglot Entrainment for Higher Dimensional Neuronal Models

Abstract: The entrainment of biological oscillators is a classic problem in the field of dynamical systems and synchronization. Our work explores a novel type of entrainment mechanism referred to as polyglot entrainment (multiple disconnected 1:1 regions) for higher dimensional nonlinear systems. Polyglot entrainment has been recently explored only in two-dimensional slow-fast models in the vicinity of Hopf bifurcations (HB). Heading towards generality, in this research, we investigate the phenomenon of polyglot entrainment in higher-dimensional conductance-based models including the four-dimensional Hodgkin-Huxley (HH) model and its reduced three-dimensional version. We utilize dynamical systems tools to uncover the mechanism of entrainment and geometric structure of the null surfaces to explore the conditions for the existence of polyglot entrainment in these models. In light of our findings, in the vicinity of HB, when an unforced system acts as a damped oscillator and the fixed point is located near a cubic-like manifold, polyglot entrainment is observed.

Sean Campbell
University of Houston
Noisy Delay Denoises Biochemical Oscillators

Abstract: Genetic oscillations are generated by delayed transcriptional negative feedback loops, wherein repressor proteins inhibit their own synthesis after a temporal production delay. This delay is distributed because it arises from a sequence of noisy processes, including transcription, translocation, translation, and folding. Because the delay determines repression timing and, therefore, oscillation period, it has been commonly believed that delay noise weakens oscillatory dynamics. Here, we demonstrate that noisy delay can surprisingly denoise genetic oscillators. Specifically, moderate delay noise improves the signal-to-noise ratio and sharpens oscillation peaks, all without impacting period and amplitude. We show that this denoising phenomenon occurs in a variety of well-studied genetic oscillators, and we use queueing theory to uncover the universal mechanisms that produce it.

Cristian Meraz

University of Houston

Existence of Weak Solutions for the Nonlocal Klausmeier Model

Abstract: We establish the existence and uniqueness of weak solutions for a nonlocal Klausmeier model within a small-time interval $[0, T)$. The Klausmeier model comprises a system of coupled, nonlinear partial differential equations governing plant biomass and surface water dynamics in semiarid regions. Unlike the original model, which posits classical diffusion for plant biomass spread, we opt for a nonlocal diffusive operator in alignment with ecological field data that validates long-range dispersive behaviors of plants and seeds. The equations, defined on a finite interval in $\mathbb{R}$, feature homogeneous Dirichlet boundary conditions for the surface water equation and nonlocal Dirichlet constraints for the plant biomass equation. We assume the nonlocal operator is described by a symmetric and spatially extended convolution kernel possessing mild integrability and regularity properties. To establish existence and uniqueness, we employ the Galerkin method with a nontraditional approach. The key challenge arises from the nonlocal operator being defined on a subspace of L^{2} instead of H^{1}, precluding the use of Aubin's compactness theorem for weak convergence of nonlinear terms. To overcome this, we introduce a new equation for the spatial derivative of plant biomass. This procedure allows us to recover enough regularity to establish compactness and complete the proof of weak convergence for the approximate solutions within the specified small-time interval $[0, T)$.

Haniyeh Fattahpour

Georgia State University

Modeling Cellular Growth within a Tissue-Engineering Scaffold Pore

Abstract: Tissue-engineering scaffolds contain channels lined by cells that allow nutrient-rich culture medium to pass through to encourage cell proliferation. Several factors have significant impacts on the tissue growth, including the nutrient flow rate and concentration in the feed, scaffold elasticity as well as cell properties. Recent studies have investigated these effects separately; however, in this work, we examine all of them simultaneously. Our objectives in this work are as follows: (i) developing a mathematical model describing the nutrient flow dynamics and concentration, scaffold elasticity and cell proliferation; (ii) solving the model and then simulating the cell proliferation process; (iii) optimizing the initial configuration of the scaffold channels to maximize the cell growth. The results of our study demonstrate that the rate of nutrient consumption by the cells (cell hunger rate) and the scaffold elastic compliance have an impact on tissue growth, with higher cell hunger rates leads to longer incubation periods, while scaffold elastic compliance slightly affects overall growth. Furthermore, decreasing the scaffold elastic compliance while maintaining a constant nutrient consumption rate results in an optimal funnel-shaped channel geometry, where the upper part of the channel is larger than the downstream, promoting enhanced tissue integration and functionality.

Hamed Karami **Georgia State University**

Mathematical modeling of bubbles in flow streams and porous media

Abstract: In many multi-phase chemical and electrochemical reaction systems, the fluid streams with dissolved gas or gas bubbles flow alongside a thin flat sheet of porous medium, composed of materials with varying surface energies. Chemical and electrochemical reactions occur at the surface and interface between the porous material and fluid. As such, the more surface is wetted, the more reaction can proceed, therefore, it is desirable to completely wet the porous material with the liquid phase. However, the gas bubbles and their dynamics can reduce the surface area of the porous material in contact with the liquid phase.

The goal of this poster is to understand the dynamics of bubble interactions and dissolved gas within the porous material, in order to optimize processes and designs.

Emeka Mazi **Georgia State University**

Mathematical modeling for understanding deposition and erosion dynamics in a branching pore structure.

Abstract: Deposition and erosion are fundamental processes in fluid dynamics, and they play a crucial role in various natural phenomena and engineered systems. These processes involve the transport of particles by the fluid flow, resulting in erosion of materials from one location and their subsequent deposition at another. In this study, we propose a mathematical model to simulate the deposition and erosion processes occurring in a porous medium represented by an idealized structure composed of bifurcating cylindrical channels, featuring two types of branching: symmetric and asymmetric. The fluid flow within the channels is governed by the Stokes equations, while the transport, deposition and erosion of solid particles are described by an advection-diffusion equation.

Furthermore, we investigated the effects of deposition and erosion processes on the evolution of the porous medium internal morphology

Alex Rodriguez **Florida International University**
Nonlinear Schrödinger equation with infinite nonlinearities

Abstract: We consider NLS equation with combined nonlinearities, possibly with infinitely many terms, allowing analytical potentials, such as an exponential nonlinearity. We first discuss local well-posedness for any power in a weighted subset of Sobolev space, and then extend it to global well-posedness using the pseudo-conformal transformation. We then prove scattering for initial data with a quadratic phase and discuss a possible threshold for the global vs finite time existence.

Chandler Haight **Florida International University**
Investigations of Korteweg-de Vries Type Equation Breather Solutions

Abstract: We characterize and investigate breather solutions to the Korteweg-de Vries (KdV) type equations via numerical simulation, ranging from the integrable systems to Hamiltonian systems. Our numerical simulation results suggest that the absolute value in the potential term is the key factor in forming the breather solutions in the generalized KdV case. Moreover, these breather solutions are stable under various perturbations. These numerical results are consistent with a few known theoretical stability results for the integrable systems indicating the future studies of the breather solutions for the general Hamiltonian systems.

Francis Baffour-Awuah **Florida State University**
Optimizing Antibiotic Treatment Strategies for Osteomyelitis: Insights from Optimal Control Theory

Abstract: Osteomyelitis, primarily caused by Staphylococcus bacteria, presents diverse clinical manifestations often requiring multifaceted treatment approaches, including surgical intervention. However, early diagnosis of the condition can facilitate effective antibiotic treatment, particularly in children. Challenges persist in determining optimal drug delivery methods, dosage regimens, and treatment durations. This presentation explores the application of optimal control theory to optimize antibiotic treatment strategies for osteomyelitis. Our objective is to devise treatment protocols that minimize bacterial proliferation, therapeutic costs, and medication-related adverse effects. Our analyses reveal that a gradually tapered antibiotic dosing regimen is cost-effective compared to constant dosing, mitigating the risk of undesirable side effects. Additionally, we highlight the nuanced relationship between pathogen eradication and inflammation resolution, emphasizing the complexities inherent in osteomyelitis management.

Savas Sardelis **Florida State University**
Pure Quartic Soliton with PT-symmetric Nonlinearity

Abstract: Pure quartic solitons represent a distinctive category of solitary waves arising from the interplay between negative quartic dispersion and Kerr nonlinearity. This study presents a comprehensive numerical and theoretical investigation aimed at elucidating a novel class of pure quartic solitons. Specifically, we establish a theoretical framework that highlights the crucial role of balancing nonlinear effects within a parity-time symmetric self-induced potential against quadratic dispersion or diffraction. Furthermore, we offer a comparative analysis by juxtaposing our findings with traditional pure quartic solitons governed solely by Kerr nonlinearity.

Jonathan Engle **Florida State University**
The impact of Zealots and Consensus makers in voting and consensus games

Abstract: The outcome of democratic elections rests on individuals' decision-making that is driven by their varying preferences and sets of information. Individuals may prefer consensus to deadlock, or deadlock to consensus, and information may be fractured via echo-chambers. To understand the role of these factors in elections reaching consensus, we explore a voter game in which two parties are composed of zealots, who always vote for their party, consensus makers, who vote for the party who previously won, and strategists, who base their vote on their prediction of which party will win. Voters may change their voting strategy either by imitating others or reconsidering their strategy based on their respective payoffs. We consider various preference orderings of one's own party winning, the opposing party winning, and deadlock, and we also consider different information networks where knowledge of the voting behavior of others is incomplete and heterogeneous. We show that zealots and consensus-makers dominate over long time if the rate of imitation of others is low and consensus can frequently be reached. When this is not the case, zealots dominate and thus deadlock is unavoidable.
Furthermore, we show that consensus is promoted by an uneven distribution of party membership, and undermined when it is even. Strategists also undermine consensus regardless of preference to gridlock over party alignment.