Third Joint Alabama–Florida Conference on Differential Equations, Dynamical Systems and Applications

University of Alabama Birmingham
May 20–22, 2025

Organizing Committee

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National Science Foundation
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Venue Information

- The conference talks, coffee breaks, and lunches will take place in University Hall on UAB campus, rooms 1005, 4002, 4004. **Enter the building on the pedestrian "green" side (first floor level).** Street side entrance is on the second floor and requires card access. Address: 10th Ave S, Birmingham, AL 35294

- Free parking is available on 14th street, as well as on 13th avenue close to the UAB Police Department, as well as at various locations right next to University Hall.
  Address: 1117 14th St S, Birmingham, AL 35205 (UAB Police Department).
  Metered parking is also available.

- The poster session will be held in the second floor lobby of University Hall.

- There will be a conference dinner at 7:00 PM on May 21 held at The Fish Market Restaurant. This is 5 min walk from both conference hotels.
  Address: 612 22nd Street South, Birmingham, AL 35233.

- Campus map:

Conference Schedule

Preliminary Day for Graduate Students

Tuesday, May 20		
Location	Event	Time
UH 1005	Registration and Breakfast	8:30AM-9:00AM
UH 1005	Dmitry Pelinovsky, Lecture 1	9:15AM-10:30AM
UH 1005	Coffee Break	10:30AM-10:45AM
UH 1005	Arnd Scheel, Lecture 1	10:45AM-noon
UH Main Lobby	Lunch[1]	noon-12:30PM
UH 1005	Panel Discussion	12:30PM-1:30PM
UH 4002	Arnd Scheel, Lecture 2	1:45PM-3:00PM
UH 4101	Coffee break	3:00PM-3:15PM
UH 4004	Dmitry Pelinovsky, Lecture 2	3:15PM-4:30PM
Restaurants[2]	Dinner[3]	5:30PM

[1] Taziki's
[2] Vocelli Pizza, Pita Stop, Bay Leaf Indian, Surin West, Dreamland BBQ
[3] Participants will organize in groups for various restaurants

Conference Schedule		
Wednesday, May 21		
Location	Event	Time
UH 1005	Plenary - P. Kevrekidis	8:30AM-9:30AM
UH 1005	Chongchun Zeng	9:30AM-10:00AM
Main Lobby	Coffee break	10:00AM-10:30AM
UH 1005	Arnd Scheel	10:30AM-11:00AM
UH 1005	Olivia Clifton	11:00AM-11:30AM
UH 1005	Merlin Pelz	11:30AM-12:00PM
Main lobby	Lunch - Mr.Shawarma	12:00PM-1:00PM
UH 1005	Plenary - M. Weinstein	1:00PM-2:00PM
UH 1005	Mat Johnson	2:00PM-2:30PM
UH 1005	Anna Ghazaryan	2:30PM-3:00PM
Main Lobby	Coffee break	3:00PM-3:30PM
UH 1005	Dmitry Pelinovsky	3:30PM-4:00PM
UH 1005	Dionyssios Mantzavinos	4:00PM-4:30PM
UH 1005	Abdon Moutinho	4:30PM-5:00PM
Second floor lobby	Poster Session	5:00PM-6:30PM
Fish Market Restaurant	Conference Dinner/ Banquet	7:00PM-9:00PM
Thursday, May 22		
UH 1005	Plenary - W. Schlag	8:30AM-9:30AM
UH 1005	Sam Walsh	9:30AM-10:00AM
Main Lobby	Coffee break	10:00AM-10:30AM
UH 1005	Yuri Latushkin	10:30AM-11:00AM
UH 1005	Ian Miller	11:00AM-11:30AM
UH 1005	Hewan Shemtaga	11:30AM-12:00PM
Main Lobby	Lunch - Taco Mama	12:00PM-1:00PM
UH 1005	Plenary - N. Pavlovic	1:00PM-2:00PM
UH 1005	Vahagn Manukian	2:00PM-2:30PM
UH 1005	Justin Valleta	2:30PM-3:00PM
UH 1005	Aseel Farhat	3:00PM-3:30PM

Titles and abstracts

Soliton and Vortex Patterns: From BECs to Quantum Droplets & Beyond

SPEAKER: Panos Kevrekidis , *University of Massachusetts*

SCHEDULED: Wednesday, May 21, 8:30 AM-9:30 AM at UH 1005

DETAILS: Plenary Talk

ABSTRACT: In the present talk, I will start from an overview of earlier studies in 1-component and 2-component atomic Bose-Einstein condensates driven from experimental developments over the past 15 years that have led to a systematic understanding of the motion of quasi-one-dimensional dark solitons (DS) and quasi-two-dimensional vortex solitons (VS) in such settings. The evolution of single DS and VS in trapped environments and the pairwise interaction of multiple such structures and their comparison with numerical computations and experimental data will be presented. Then, we will move to a more recent generation of experiments capturing the role of quantum fluctuation induced corrections. The mathematical challenges that these recent experiments pose at the level of competition of focusing and defocusing nonlinearities will be highlighted, some opportunities at the level of the creation of novel structures (droplets, bubbles, kinks, etc.) will be explored and finally some intriguing mathematical features, such as the transverse stability in higher dimensions of kinks will be discussed.

Water waves linearized at monotonic shear flows

SPEAKER: Chongchun Zeng, *Georgia Institute of Technology*

SCHEDULED: Wednesday, May 21, 9:30 AM–10:00 AM at UH 1005

ABSTRACT: We consider the 2-dim water wave problem – the free boundary problem of the Euler equation with gravity and possibly surface tension – of finite depth linearized at a uniformly monotonic shear flow. The main focus of this talk is the eigenvalue distribution. We start with the bifurcation of unstable modes from limiting singular neutral modes, then the eigenvalues corresponding to high wave numbers, and finally obtain a complete picture of spectral distribution under certain conditions. The inviscid damping of the linearized capillary gravity waves would be discussed briefly if time permits. This is a joint work with Xiao Liu.

Spatial Heterogeneity and Striped Phases

SPEAKER: Arnd Scheel , *University of Minnesota*

SCHEDULED: Wednesday, May 21, 10:30 AM-11:00 AM at UH 1005

ABSTRACT: I will discuss the effect of spatial inhomogeneities on striped phases, focusing mostly on spatially localized disturbances but as time permits mention spatial gradients. Technically, the problem here is to describe a "spatial center manifold" at spatial infinity and asymptotics of solutions within this manifold, in particular when spatial infinity is higher-dimensional. Our results describe these dynamics in terms of multipole expansions but also point to a more general algebra for these infinite-dimensional asymptotics.

Selection of interface angles through directional quenching – an Allen-Cahn system

SPEAKER: Olivia Clifton, *University of Illinois Urbana-Champaign*

SCHEDULED: Wednesday, May 21, 11:00 AM–11:30 AM at UH 1005

ABSTRACT: One motivation for studying Allen-Cahn systems is that evolution of interfaces approximates mean-curvature flow. We consider two competing effects on interfaces in a quenched planar Allen-Cahn system, where the quenching in the right half-plane can be thought of as a kind of boundary effect. First, we consider an asymmetry in the nonlinearity, which corresponds to driven mean-curvature flow; and second, translation of the quenching line. We find, for speeds and asymmetries of the same small order, that the quenching speed uniquely determines the farfield angle of a solution with asymptotically straight interface. This result can be interpreted as finding the effective boundary condition from the quenching line for the mean-curvature flow in the farfield.

Symmetry-Breaking and Synchronized Memory-Dependent Oscillations in Compartmental-Reaction Diffusion Systems

SPEAKER: Merlin Pelz *University of Minnesota*

SCHEDULED: Wednesday, May 21, 11:30 AM-12:00 PM at UH 1005

ABSTRACT: The Kuramoto model has been used in the last decades to gain insight into the behavior of coupled discrete oscillators, as it is simple enough to be analyzed and exhibits a breadth of possible behaviours, such as synchronization, oscillation quenching, and chaos. However, the question arises how one can derive precise coupling terms between spatially localized oscillators that interact through a time-dependent diffusion field. We focus on a compartmental-reaction diffusion system with nonlinear intracellular kinetics of two species inside each small and well-separated cell/compartment with reactive boundary conditions. For the case of one-bulk diffusing species in $\mathbb{R}^2$, we derive a new memory-dependent integro-ODE system that characterizes how intracellular oscillations in the collection of cells are coupled through the PDE bulk-diffusion field. By using a fast numerical approach relying on the "sum-of-exponentials" method to derive a time-marching scheme for this nonlocal system, diffusion induced synchrony (in-phase, anti-phase, mixed-mode etc.) is examined for various spatial arrangements of cells. This theoretical modeling framework, relevant when spatially localized nonlinear oscillators are coupled through a PDE diffusion field, is distinct from the traditional Kuramoto paradigm for studying oscillator synchronization on networks or graphs. It opens up new avenues for characterizing synchronization phenomena associated with various discrete oscillatory systems in the sciences, such as quorum-sensing behavior. In the case of two diffusing species, our pattern formation results reveal a possible simple mechanism for the ubiquitous biological cell specialization observed in nature. (This is joint work with Michael J. Ward.)

Quantum tunneling in magnetic systems

SPEAKER: Michael Weinstein, *Columbia University*

SCHEDULED: Wednesday, May 21, 1:00 PM-2:00 PM at UH 1005

DETAILS: Plenary Talk

ABSTRACT: Quantum tunneling is a phenomenon which plays an important role in, for example, physical, chemical and biological processes. Further, the control of tunneling is central to quantum technologies. Its mathematical paradigm is the Schroedinger operator with a symmetric double-well potential.

It has been understood since the early days of quantum mechanics that, in the absence of a magnetic field, the quantum particle's wave function always tunnels from one well into the neighboring well through a "classically forbidden" region. Further, the tunneling-time is related to the reciprocal of the (non-zero but exponentially small) "eigenvalue splitting".

In this talk I'll present recent results on quantum tunneling in 2D systems in the presence of a strong, constant and perpendicular magnetic field.

We construct a family of double well potentials containing examples for which the eigenvalue splitting vanishes, and hence quantum tunneling is completely eliminated. I'll remark on possible implications of this phenomenon. In contrast, magnetic tunneling does occur for typical double-well potentials, and we prove an upper bound on its tunneling time. This is joint work with C.L. Fefferman and J. Shapiro (PNAS, 122(8) 2025).

Modulational Dynamics of Wave Trains in the Ostrovsky Equation

SPEAKER: Mathew A Johnson, *University of Kansas*

SCHEDULED: Wednesday, May 21, 2:00 PM-2:30 PM at UH 1005

ABSTRACT: In this talk, I describe results concerning the modulational dynamics and stability of periodic traveling wave solutions in the Ostrovsky equation. The techniques utilized are quite general, relying primarily on ODE techniques and spectral perturbation theory.

On the spectrum of the front in a predator-prey model

SPEAKER: Anna Ghazaryan, *Miami University*

SCHEDULED: Wednesday, May 21, 2:30 PM-3:00 PM at UH 1005

ABSTRACT: We consider a predator-prey model with diffusion. Depending on the parameter regime, phenomenologically different types of fronts exist in this model. In particular, in the situation when the prey diffuses at the rate much smaller than that of the predator, there exists a parameter regime when the underlying dynamical system in a singular limit is reduced to a scalar equation. The process of the reduction consists of taking limits with respect to two parameters. In this presentation, the stability of these fronts is discussed. In particular, it is focused on obtaining uniform in the singular parameters bounds on the discrete spectrum.

Instability of the peaked traveling wave in a local model for shallow water waves

SPEAKER: Dmitry Pelinovsky, *McMaster University*

SCHEDULED: Wednesday, May 21, 3:30 PM-4:00 PM at UH 1005

ABSTRACT: The traveling wave with the peaked profile arises in the limit of the family of traveling waves with the smooth profiles. We study the linear and nonlinear stability of the peaked traveling wave by using a local model for shallow water waves, which is related to the Hunter–Saxton equation. The evolution problem is well-defined in the function space $H^1_{per} \cap W^{1,\infty}$, where we derive the linearized equations of motion and study the nonlinear evolution of co-periodic perturbations to the peaked periodic wave by using methods of characteristics. Within the linearized equations, we prove the spectral instability of the peaked traveling wave from the spectrum of the linearized operator in a Hilbert space, which completely covers the closed vertical strip with a specific half-width. Within the nonlinear equations, we prove the nonlinear instability of the peaked traveling wave by showing that the gradient of perturbations grow at the wave peak. By using numerical approximations of the smooth traveling waves and the spectrum of their associated linearized operator, we show that the spectral instability of the peaked traveling wave cannot be obtained in the limit along the family of the spectrally stable smooth traveling waves. This is a joint work with Fábio Natali and Shuoyang Wang.

Linear and Nonlinear Dispersive Equations in Domains with a Boundary

SPEAKER: Dionyssis Mantzavinos, *University of Kansas*

SCHEDULED: Wednesday, May 21, 4:00 PM-4:30 PM at UH 1005

ABSTRACT: A plethora of physical phenomena are modeled by partial differential equations (PDEs). In the case of waves in water, optical fibers, Bose-Einstein condensates, or other media, one encounters the phenomenon of dispersion, namely waves of different frequencies propagating at different speeds. The associated PDEs are referred to as dispersive, and their analysis has been at the center of interest within the broader PDE/harmonic analysis/nonlinear waves communities during the past fifty years. In this talk, we will emphasize the importance of studying dispersive PDEs in the presence of nonzero boundary conditions. Such conditions are directly motivated by applications that take place in domains with a boundary, either in nature or in the laboratory. The relevant problems are known as initial-boundary value problems and their study turns out to be significantly more involved than the one of the more standard initial value problems, which take place on fully unbounded domains. Fundamental dispersive PDEs like the nonlinear Schrödinger and the Korteweg-de Vries equations will serve as motivating examples in order to guide us through the main steps of the analysis.

Dispersive analysis for one-dimensional charge transfer models

SPEAKER: Abdon Moutinho, *Georgia Tech*

SCHEDULED: Wednesday, May 21, 4:30 PM-5:00 PM at UH 1005

ABSTRACT: In this paper, we study one-dimensional Schrödinger equations with multiple moving potentials, known as transfer charge models. Focusing on the non-self-adjoint setting, which arises in the study of solitons, we establish asymptotic completeness and dispersive estimates under the assumption that the potentials move at significantly different velocities, even in the presence of unstable modes. Our analysis set up the fundamental work for studying the nonlinear dynamics of multi-solitons, including asymptotic stability and collisions.

Poster Session: see separate abstracts list

SCHEDULED: Wednesday, May 21, 5:00 PM-6:30 PM Second Floor Lobby

Stability analysis of topological solitons and applications of the distorted Fourier transform

SPEAKER: Wilhelm Schlag , *Yale University*

SCHEDULED: Thursday, May 22, 8:30 AM-9:30 AM at UH 1005

DETAILS: Plenary Talk

ABSTRACT: We will review some orbital and asymptotic stability results in Hamiltonian equations. A common tool in asymptotic stability proofs is given by the distorted Fourier transform. We will briefly review how this tool is derived and describe some of its applications. A particular challenge is to develop this tool for non-selfadjoint matrix operators which commonly arise when linearizing a nonlinear Schrödinger equation around a soliton. Much of the talk will deal with a particular instance of this problem in the setting of Ginzburg-Landau vortices.

SPEAKER: Samuel Walsh , *University of Missouri*

SCHEDULED: Thursday, May 22, 9:30 AM-10:30 AM at UH 1005

ABSTRACT:

The Duistermaat index, eigenvalue interlacing for self-adjoint extensions of symmetric operators, and Morse indices of Hermitian matrices

SPEAKER: Yuri Latushkin, *University of Missouri*

SCHEDULED: Thursday, May 22, 10:30 AM-11:00 AM at UH 1005

ABSTRACT: Eigenvalue interlacing is a useful tool in linear algebra and spectral analysis. In its simplest form, the interlacing inequality states that a rank-one positive perturbation shifts each eigenvalue up, but not further than the next unperturbed eigenvalue. We discuss a sharp version of the interlacing inequalities for "finite-dimensional perturbations in boundary conditions," expressed as bounds on the spectral shift between two self-adjoint extensions of a fixed symmetric operator with finite and equal defect numbers. The bounds are given in terms of the Duistermaat index, a topological invariant describing the relative position of three Lagrangian planes in a symplectic space. We give an axiomatic description of the Duistermaat index, study its connections to the Maslov index and give applications to a formula for the Morse indices of a difference of Hermitian matrices. This is a joint work with G. Berkolaiko, G. Cox and S. Sukhtaiev

Global dynamics for Solutions of the Nonlinear Schrödinger Equation with Nonzero Angular Momentum

SPEAKER: Ian Miller, *University of Colorado Boulder*

SCHEDULED: Thursday, May 22, 11:00 AM-11:30 AM at UH 1005

ABSTRACT: We consider the problem of global existence versus blow up for certain nonlinear Schrödinger equations, including the 3d cubic equation. Over the past two decades, this problem has received significant attention, and for solutions having energy below that of a ground state standing wave, the problem is almost entirely resolved. The problem of global dynamics for large energy solutions, however, remains mostly open. Momentum contributing to concentration or dispersion has been identified as a useful quantity for establishing control in one time direction for large energy solutions. We show that the conserved quantity of angular momentum can also be used to control solutions. We describe new methods relating to momentum of solutions and discuss how they can be used to obtain new global existence and blow up results for large energy solutions. These results include the establishment of arbitrarily large energy solutions that exist globally, and in fact scatter, in both time directions.

Front Propagation Dynamics in Fisher KPP Equations on Unbounded Metric Graphs

SPEAKER: Hewan Shemtaga, *Auburn University*

SCHEDULED: Thursday, May 22, 11:30 AM-12:00 PM at UH 1005

ABSTRACT: This talk focuses on the front propagation dynamics of Fisher-KPP equations on unbounded metric graphs. There are several studies on front propagation phenoman in bistable equations on unbounded metric graphs. It is known that, in such equations, the network structure of the underlying environment may block the propagation of the fronts. It will be shown in this talk that the network structure of the environments does not block the propagation of the fronts in Fisher-KPP equations. Specifically, we will show that on an unbounded metric graph with finitely many edges, the Fisher-KPP equation exhibits the same minimal spreading speed c^* as on the real line. Moreover, it admits a generalized traveling wave connecting the stable positive constant solution and the trivial solution, with an averaged speed c for any $c > c^*$. This is a joint work with Dr. Wenxian Shen and Dr. Selim Sukhtaiev.

On large Bose-Fermi mixtures

SPEAKER: Natasa Pavlovic , *University of Texas at Austin*

SCHEDULED: Wednesday, May 22, 1:00 PM-2:00 PM at UH 1005

DETAILS: Plenary Talk

ABSTRACT: Investigating mixtures of bosons and fermions is an extremely active area of research in experimental physics for constructing and understanding novel quantum bound states such as those in superconductors, superfluids, and supersolids. These ultra-cold Bose-Fermi mixtures are fundamentally different from gases with only bosons or fermions. They not only show an enriched phase diagram, but also a fundamental instability due to energetic considerations coming from the Pauli exclusion principle. Inspired by this activity in the physics community, recently we started exploring the mathematical theory of Bose-Fermi mixtures.

- One of the main challenges is understanding the physical scales of the system that allow for suitable analysis. We will describe how we overcame this challenge in the joint work with Esteban Cárdenas and Joseph Miller by identifying a novel scaling regime in which the fermion distribution behaves semi-clasically, but the boson field remains quantum-mechanical. In this regime, the bosons are much lighter and more numerous than the fermions.
- Time permitting, we will also describe new results obtained with Esteban Cárdenas, Joseph Miller and David Mitrouskas inspired by recent experiments by DeSalvo et al. on mixtures of light fermionic atoms and heavy bosonic atoms. A key observation - and this has been theoretically long predicted - is the emergence of an attractive fermion-mediated interaction between the bosons. We give a rigorous derivation of fermion-mediated interactions and prove the associated stability-instability transition.

KPP-Burgers fronts in an SIS model

SPEAKER: Vahagn Manukian, *Miami University*

SCHEDULED: Thursday, May 22, 2:00 PM-2:30PM at UH 1005

ABSTRACT: In a diffusive SIS model, when the infected population diffuses faster than the susceptible population, we derive a bound for the speeds of the fronts in this regime in which the infection propagates as a front. Moreover, for the classical SIS model we show that there is a case when the spread of the disease is governed by the Burgers-FKPP equation.

Breakdown of the higher-order EPDiff equation

SPEAKER: Justin Valleta , *Florida State University and Wake Forest University*

SCHEDULED: Wednesday, May 22, 2:30 PM-3:00 PM at UH 1005

ABSTRACT: A certain family of PDEs, called EPDiff equations, can be realized as the geodesic equation of the right-invariant Sobolev metric of order k on the diffeomorphism group of $\mathbb{R}^n$. The EPDiff equation generalizes the classic one-dimensional models in fluid dynamics, such as Burgers', the Camassa-Holm, and the Hunter-Saxton equation. By exploiting the geometric framework, we obtain a breakdown criteria for solutions to EPDiff equations. Our approach relies on considering radial solutions and using Lagrangian coordinates to convert the EPDiff equation to an ODE on a Banach space, thereby obtaining C^1-blowup of the velocity field solution by direct comparison with the Liouville equation. In addition to reproducing known breakdown results for the one-dimensional fluid models, we demonstrate the novelty of our criteria by applying it to EPDiff with the Sobolev inertia operator of order $k = 2$, where the breakdown only occurs in higher dimensions. Moreover, we can show breakdown of solutions to EPDiff with the homogeneous Sobolev inertia operator for every $0 \leq k < n/2+1$. This is joint work with Martin Bauer and Stephen Preston.

Upper Bounds on the Attractor Dimension of 2D Rotating Navier-Stokes Equations

SPEAKER: Aseel Farhat , *University of Virginia*

SCHEDULED: Wednesday, May 22, 3:00 PM-3:30 PM at UH 1005

ABSTRACT: We investigate the global attractor of the 2D rotating Navier-Stokes equations on the β-plane. While prior work showed attractor collapse to zonal flow under fast rotation, a quantitative measure of its complexity remained open. This talk presents new upper bounds on the attractor's dimension, valid for various rotation rates and consistent with the degenerate regime.

Stability of nonlinear waves in Hamiltonian systems

Speaker: Dmitry Pelinovsky, *McMaster University*

Scheduled: Tuesday, May 20, 9:15 AM - 10:30 AM, 3:15 PM - 4:30 PM at UH 4004

Abstract: I will cover the classical and modern stability analysis in Hamiltonian systems, including orbital stability of nonlinear waves, constrained minimization, and integrability methods. It also introduces innovative approaches for challenging cases, such as peaked traveling waves and solitary waves over nonzero backgrounds.

Propagation into unstable state and the marginal stability conjecture

Speaker: Arnd Scheel, *University of Minnesota*

Scheduled: Tuesday, May 20, 10:45 AM - 11:30 AM, 1:45 PM - 3:00 PM at UH 4004

Abstract: Perturbations of unstable states in spatially extended systems often evolve into propagating fronts that propagate at distinct speeds and select a distinct state in their wake. I will review results and techniques that aim at describing this selection mechanism from a dynamical systems perspective. It turns out that selected fronts are marginally stable within a family of fronts, an example of self-organized criticality, a fact that leads to a wealth of intriguing technical challenges and puzzling phenomena.

Panel Discussion: Life after applied mathematics PhD

Panelists: Sarah Browne, Kyoung Cox, Aslihan Demirkaya, Abba Ramadan

Sarah Browne, University of Kansas: I am currently an Associate Teaching Professor at the University of Kansas, coordinating calculus courses that range from 300 to 1000 students, managing GTAs, and teaching courses. My background in mathematics connects both functional analysis and topology, specifically operator algebras and K-theory. I hold a Ph.D. in Mathematics from the University of Sheffield, UK.

Prior to my current position, I was an Assistant Teaching Professor and a Teaching Postdoc at the University of Kansas, and spent two years as a postdoctoral scholar at The Pennsylvania State University.

Although I am a teaching faculty, I do also conduct some mathematical research, and have branched out to work with graphs and their connection to operator algebras in recent years. I serve on the Board for the Operator Algebras Mentor Network and I am an active senior mentor within the Network.

Kyoung Cox, Regions Bank: I am currently the Data and Analytics Manager and Vice President for the Financial Crimes department at Regions Bank, where I oversee all model development, data migration, documentation, and governance policies. My role combines strategic leadership with technical expertise in data analytics, as I work to ensure the effective application of data science principles within the financial industry. I hold a Ph.D. in Applied

Mathematics from UAB, which serves as the foundation for my work in model risk analysis and data-driven decision-making. Prior to my current role, I worked as a Model Risk Analyst at Regions, where I focused on risk-based validation for various model types, adhering to the Federal Reserve's Supervisory Guidance on Model Risk Management (SR 11-7). My work in this area has been instrumental in enhancing the risk management framework and model governance processes within the organization.

In addition to my corporate experience, I remain dedicated to advancing my knowledge in data analytics and its application in financial crimes prevention. I strive to contribute to the development of robust models that not only meet regulatory standards but also improve the accuracy and effectiveness of financial crime detection.

Aslihan Demirkaya, Amazon: I am currently a Research Scientist at Amazon, contributing my expertise as a key member of the Amazon Devices Cognitive Science Team. My background in mathematics and statistics underpins my work in data science, machine learning, and optimization, where I play a significant role in improving Amazon's demand and promotion planning processes. I hold a Ph.D. in Mathematics from the University of Kansas. Prior to joining Amazon, I spent three years at Vianai Systems, Inc., an AI company based in Palo Alto, where I worked as a research scientist. During my time there, I collaborated closely with software engineers and product managers to advance the Human-Centered AI platform, which addressed key challenges in enterprise AI. Alongside my role at Vianai, I took the initiative to teach a data science class at the University of San Francisco.

Before entering the tech industry, I was a Math Professor at the University of Hartford, where I co-authored more than 20 publications in peer-reviewed journals. I also helped to create the university's data science program, driven by my passion for making data science more accessible to individuals with a background in mathematics.

I continue to engage with the academic community, delivering lectures and organizing seminars on machine learning and deep learning. My ongoing research collaborations in differential equations, as well as my dedication to teaching and sharing knowledge, highlight my commitment to advancing both academic and industry-driven innovation in data science and AI.

Abba Ramadan, University of Alabama: I am an Assistant Professor in the Department of Mathematics at the University of Alabama. My research focuses on the analysis of partial differential equations and the calculus of variations, in particular on the existence and stability of solitary waves in dispersive models with applications in material science and fluid mechanics. Before joining the University of Alabama, I was a Postdoctoral Researcher in the same department. I worked on fundamental problems in nonlinear dispersive equations and their applications in physics and engineering. I completed my Ph.D. in Mathematics at the University of Kansas, where my research, under the supervision of Prof. Atanas Stefanov, concentrated on the existence and stability of solitary waves for nonlinear Schrödinger equations with defects. I have published extensively in peer-reviewed journals, with contributions spanning nonlinear wave models, fluid dynamics, and variational problems in mathematical physics. My work has been recognized with several awards, including the SIAM Post-Doctoral Support Award. I am also actively engaged in academic service, having co-organized workshops and symposia on mathematical modeling and partial differential equations.

In addition to my research, I am dedicated to teaching and mentoring students at various levels. I have designed and taught courses in probability, complex analysis, and differential equations, and I have supervised undergraduate research projects on topics related to nonlinear waves and numerical solutions of elliptic PDEs. I remain actively involved in the broader mathematical community through invited talks, conference presentations, and collaborative research visits.

Posters

Diffusion of elongated and deformable particles in perforated media

Presenter: Shomi Aktar, *University of Alabama*

Abstract: The diffusion of elongated and deformable particles in perforated media has broad applications in environmental science, biomedical engineering, and industrial filtration. Unlike spherical particles, elongated and flexible particles undergo complex fluid-solid interactions that significantly influence their diffusion and passage through microstructured media. In this study, we develop analytical solutions to investigate the mean first passage time for the upscaled anomalous diffusion of such particles in a perforated medium. The solution to the Helmholtz equation around multiple circular obstacles is derived as a series expansion of modified Bessel functions. The impact of parameters such as pore geometry and particle properties on particle breakthrough is analyzed, providing insights into the transport mechanisms in complex porous structures.

On the two-stage filtered Runge-Kutta discontinuous Galerkin method and its variant: Fourier analysis and local time marching

Presenter: Benjamin Atawiah, *The University of Alabama*

Abstract: In this work, we study the stability and accuracy effects of modal filters on the Runge-Kutta discontinuous Galerkin (RKDG) method and its variants for scalar hyperbolic conservation laws. We primarily focus on second-order schemes and apply the modal filters after each Runge-Kutta stage. Using a Fourier-type analysis, we quantitatively assess the stability, time-step constraints, and accuracy of multiple filtered schemes. The application of filters to the constant-coefficient linear advection equation can significantly improve CFL numbers while maintaining second-order accuracy. However, for the variable-coefficient and the non-linear Burgers equation case containing sonic points, the convergence order of some filtered schemes degrades by half an order. To address this issue, we apply filters only away from the sonic points and design a local time-marching strategy to take advantage of the larger time steps enabled by the filters in these regions.

Orbital Stability of Smooth Solitary Waves for the Novikov Equation

PRESENTER: Brett Ehrman, *University of Kansas*

ABSTRACT: We study the orbital stability of smooth solitary wave solutions of the Novikov equation, which is a Camassa-Holm type equation with cubic nonlinearities. These solitary waves are shown to exist as a one-parameter family (up to spatial translations) parameterized by their asymptotic endstate, and are encoded as critical points of a particular action functional. As an important step in our analysis we must study the spectrum the Hessian of this action functional, which turns out to be a nonlocal integro-differential operator acting on $L^2(R)$. We provide a combination of analytical and numerical evidence that the necessary spectral hypotheses always holds for the Novikov equation. Together with a detailed study of the associated Vakhitov-Kolokolov condition, our analysis indicates that all smooth solitary wave solutions of the Novikov equation are nonlinearly orbitally stable.

Inverse Scattering Transform Method to Solve Complex Space-Time Shifted Three Wave Interaction Equations

PRESENTER: Ramesh Gupta, *Florida State University*

ABSTRACT: A non-linear partial differential equation (PDE) is integrable if it is solvable by purely linear means. It is difficult to know whether a non-linear PDE is integrable or not if we try to solve by linear means as it is difficult to find the linear means associated with the non-linear PDE. By considering a system with 3×3 scattering problem and its time evolution, we can get a class of PDEs which are guaranteed to be integrable. We can get the integrable complex space-time shifted three wave interaction equations in 1+1 dimension. Then, we can solve the initial value problem for the three wave interaction equations in 1+1 dimension assuming that the initial potential decays to zero sufficiently rapidly by "Inverse Scattering Transform Method" and find 1-soliton solutions for the three wave interaction equations.

5gKdV: Local Well-Posedness for Slow Decay Data

PRESENTER: Chandler Haight, *Florida International University*

ABSTRACT: We study solutions to the higher dispersion Korteweg-de Vries (KdV)-type equation, namely, the 5th-order generalized KdV, $\partial_t u - a_1 \partial_x^5 u - a_2 \partial_x^3 u + |u|^\alpha \partial_x u = 0$ with low power nonlinearity ($0 < \alpha < 1$). Equations of this type and their more generalized form arise in modeling water waves. We obtain the local well-posedness with initial conditions in a weighted subspace of Sobolev spaces.

Spreading speed of chemotaxis model with consumption

PRESENTER: Zulaihat Hassam, *Auburn University*

ABSTRACT: I will present results on the impact of chemotaxis on the spreading speed of biological species when the mobile species consumes the chemical substance. Our findings suggest that, in general, the presence of the chemical neither impedes the species' spread nor enhances the spreading speed under certain biologically natural conditions.

On generalizing the induced surface charge method to heterogeneous Poisson-Boltzmann models for electrostatic free energy calculation

PRESENTER: Idowu Esther Ijaodoro, *The University of Alabama, Tuscaloosa*

ABSTRACT: The induced surface charges (ISC) method, which computes the induced charges on the molecular surface of macromolecules and uses them via Coulomb's law to calculate the polar solvation energy, was shown to be a robust and almost grid independent approach for electrostatic analysis based on the sharp-interface Poisson-Boltzmann (PB) model. Besides being physically intuitive, the ISC method avoids using the potential near the point charges, which is singular at each atom center. However, the ISC method cannot be physically generalized to heterogeneous dielectric PB models, due to the non-existence of a dielectric boundary. In this work, a novel far-field (FF) method is proposed to calculate the polar solvation free energy, which is derived through reformulating the energy functionals of nonlinear PB potential in solvent and vacuum states. Built upon a rigorous mathematical analysis, the FF method reconstructs the free energies by using far-field solutions outside the solute so that the self-energy terms generated by the singular charges are avoided, just as in the ISC method. Being valid for both sharp-interface and heterogeneous PB models, the performance of the proposed FF method has been validated by considering diffuse interface, Gaussian and super- Gaussian PB models for Kirkwood spheres and various protein systems. Comparison with grid-energy cancellation and regularization methods is also considered. The robustness of the FF method in treating a non-rigid biomolecule with different molecular structures in solvent and vacuum states has been explored, taking advantage of the fact that the far-field potential is insensitive to perturbations of singular charge locations.

Radiative Decay of Edge States in a Time-Forced SSH Model

PRESENTER: Remy Kassem, *Columbia University*

ABSTRACT: We study the effect of time-periodic forcing on the edge state of the semi-infinite Su–Schrieffer–Heeger (SSH) model, a 1D tight-binding model. Numerical simulations and an asymptotic expansion demonstrate that if the frequency of forcing is in resonance with the continuous spectrum of the unforced Hamiltonian, then on a time scale proportional to the inverse square of the forcing amplitude, the edge state decays in amplitude due to the radiation of its energy into the bulk. A proof is work in progress, and makes use of a new dispersive decay estimate for the time-evolution induced by the Hamiltonian.

Anchored Spirals in Sharp-Interface and Phase Oscillator Models

PRESENTER: Nan Li, *University of Minnesota*

ABSTRACT: We present results on spiral waves in a sharp-interface model where a curve, anchored with a fixed angle at a disk, rotates with a constant speed, $c = V - D\kappa$, κ curvature. We show the existence, stability and asymptotics in a limit where $0 < D \ll 1$. We also show preliminary results on existence and instability when $c = V - D\kappa + \kappa_{ss}$ with $D < 0$. From a different perspective, we also analyze the existence and stability in a phase dynamics approximation, $u_t = \Delta u + f(u)$ on the domain $r \leq |x| \leq R$, where $f(u) = f(u + 2\pi)$.

Lipschitz Stability Estimate for an Initial Wave Reconstruction Problem of Telegraph Type With Gaussian Noise

PRESENTER: Dat Thuc Nguyen, *Florida State University*

ABSTRACT: This work is devoted to the study of an initial wave reconstruction problem of telegraph type. Our specific goal is to determine the initial spikes of an idealized signal in a telegraph wire from two consecutive observations contaminated by Gaussian noise. Our main result shows that the initial reconstruction is Lipschitz stable in the expectation operator. The proof relies upon the integral representation of solution for Cauchy data, together with the use of the truncated Fourier approximator. Additionally, we prove that the reconstructed initial data are exactly observable. Some numerical tests are given to validate our theoretical findings.

Solutions to the NLS with higher order dispersion and low power of nonlinearity

PRESENTER: Iryna Petrenko, *Florida International University*

ABSTRACT: We study a *higher order* dispersion nonlinear Schrödinger (NLS) equation with the k-Laplacian $(-\Delta)^k$, and the potential term expressed as a power nonlinearity (for any positive power). When $k = 1$ we recover the NLS with the standard Laplacian and when $k = 2$ we get the bi-harmonic NLS. We investigate well-posedness of solutions to this higher order NLS equation on a subset of a Sobolev space by constructing a weighted space with polynomial weights. We also numerically study the behavior of solution.

Pattern-forming Fronts in the Wake of a Parameter Ramp

PRESENTER: Kiersten Ratcliff, *University of Alabama at Birmingham*

ABSTRACT: We use numerical and analytical methods to study the formation of patterns in the photochemical CDIMA system in the presence of a slowly-varying light-mask which progressively excites a Turing instability. In contrast to previous work using a sharp mask to control the formation of patterns, we study the behavior of the system in one- and two- dimensions under a novel slowly-varying parameter. This induces an asymptotically constant front from which Turing patterns can form in the wake. We simulate the system numerically in one- and two-dimensions and find that, in Turing-unstable parameter regimes, wavenumber selection curves under a slow-ramp parameter significantly differ from those under a piecewise-constant parameter. This is further confirmed using pseudo-arc-length continuation. We then theoretically study the relationship between the slowly-ramped CDIMA and an analogous complex Ginzburg-Landau equation. In the latter equation, we use geometric singular perturbation and invariant manifold theory to construct pattern forming fronts and determine wavenumber selection curves. We observe a change in the shape of the manifold at a critical parameter value, determined by the absolute instability threshold of the trivial state.

Pure-Quartic Solitons with PT-Symmetric Nonlinearity

PRESENTER: Savvas Sardelis, *Florida State University*

ABSTRACT: The idea of having solitary waves in Kerr nonlinear media arising in the presence of only quartic dispersion was briefly theoretically considered in the early 90's and then almost forgotten until its experimental discovery in 2016. These so-called pure-quartic solitons (PQS) were observed in a silicon photonic crystal waveguide where quartic dispersion was the dominant dispersion effect and all the other dispersion orders were negligible. We propose a new class of soliton based on the interaction of parity-time (PT) symmetric nonlinearity and quartic dispersion or diffraction. This novel kind of soliton is related to the recently discovered pure-quartic solitons, that arise from the balance of Kerr nonlinearity and quartic dispersion, through a complex coordinate shift. We find that the PT-symmetric pure-quartic soliton presents important differences with respect to its Hermitian (Kerr) counterpart, including a nontrivial phase structure, a skewed spectral intensity, and a higher power for the same propagation constant. Further analysis reveals these solitons are linearly stable.

NLS/GP Solutions on the Half-Line: Bifurcation Theory, Spectral Theory, and Variational Analysis

PRESENTER: Jackson Turner, *Columbia University*

ABSTRACT: We study standing-wave solutions to the NLS/GP equation on the half-line with a Dirichlet boundary condition, focusing on the interplay between a cubic nonlinearity and a linear potential. First, in the absence of linear bound states in the potential, we prove that the frequency and L^2 norm of standing-wave solutions are bounded away from zero. Second, we show that linear resonances on the imaginary axis generate distinct solution branches: scattering resonances nucleate branches localized at infinity, while bound states give rise to branches bifurcating from zero norm. Finally, we present variational results characterizing the stability of these solutions and identifying global minimizers of the Hamiltonian energy under norm constraints.

Conference participants

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65. Jackson Turner, Columbia University
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67. Justin Valletta, Florida State University and Wake Forest University
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