2023 SIAM Texas-Louisiana Sectional Meeting

Department of Mathematics
University of Louisiana at Lafayette
Lafayette, Louisiana, USA

November 3-5, 2023 (Friday-Sunday)

Contents

Organizing Committees

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- Azmy Ackleh, Department of Mathematics and Dean, R.P. Authement College of Sciences, University of Louisiana at Lafayette
- Hayriye Gulbudak, Department of Mathematics, University of Louisiana at Lafayette
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- Shawn W. Walker, Department of Mathematics and Center for Computation & Technology (CCT), Louisiana State University
- John Zweck, Department of Mathematical Sciences, The University of Texas at Dallas

Timetable

Friday (11/3)

- 02:00 pm-05:00 pm Registration (Oliver)
- 03:00 pm-05:00 pm Mini-Symposia (Griffin and Oliver)
- 05:00 pm-05:15 pm Refreshments (Griffin and Oliver)
- 05:15 pm-06:15 pm Plenary Lecture (Griffin 147)
- 06:15 pm-07:00 pm Career Panel (Griffin 315)

Saturday (11/4)

- 08:00 am-10:00 am Registration (Oliver) & Refreshments (Griffin and Oliver)
- 08:30 am-09:30 am Plenary Lecture (Griffin 147)
- 09:30 am-09:45 am Refreshments (Griffin and Oliver)
- 09:45 am-11:45 am Mini-Symposia (Griffin and Oliver)
- 11:45 am-01:30 pm Lunch Break
- 11:45 am-01:30 pm Poster Set-Up (Griffin 1st and 2nd floors)
- 12:30 pm-01:30 pm Mentoring Event (Griffin 315)
- 01:30 pm-03:30 pm Mini-Symposia (Griffin and Oliver)
- 03:30 pm-03:45 pm Refreshments (Griffin and Oliver)
- 03:45 pm-04:45 pm Mini-Symposia (Griffin and Oliver)
- 04:55 pm-05:55 pm Plenary Lecture (Griffin 147)
- 05:55 pm-06:25 pm Poster Session (Griffin 1st and 2nd floors)
- 06:30 pm-08:00 pm Banquet (Atchafalaya Room, Student Union)

Sunday (11/5)

- 08:30 am-09:30 am Plenary Lecture (Griffin 147)
- 09:30 am-09:45 am Refreshments (Griffin and Oliver)
- 09:45 am-10:45 am Mini-Symposia (Griffin and Oliver)
- 10:45 am-11:00 am Refreshments (Griffin and Oliver)
- 11:00 am-01:00 pm Mini-Symposia (Griffin and Oliver)

Abstracts of Plenary Lectures

Susanne C. Brenner, Louisiana State University

Time: Saturday (11/4) 04:55 pm - 05:55 pm
Venue: Griffin 147
Title: DD-LOD

Abstract: DD-LOD is a multiscale finite element method for problems with rough coefficients that is based on a domain decomposition approach to the localized orthogonal decomposition methodology. I will present the construction and analysis of DD-LOD for elliptic boundary value problems with rough coefficients that only require basic knowledge of finite element methods, domain decomposition methods and numerical linear algebra. An application to elliptic optimal control problems will also be discussed.

Dr. Brenner earned a Ph.D. in mathematics from the University of Michigan, 1988. She is a Louisiana State University System Boyd Professor. She holds a joint appointment with the Department of Mathematics and Center for Computation and Technology (CCT). At CCT she serves as the Associate Director for Academic Affairs.
During 2021-2022 she served as President of the Society for Industrial and Applied Mathematics (SIAM). Currently she is serving a one year term as Past President. In 2005 she was awarded a Humboldt-Forschungspreis (Humboldt Research Award) from the German Alexander von Humboldt Foundation. In 2011 she was awarded the AWM-SIAM Sonia Kovalevsky Lecture Prize. She is a SIAM Fellow (Class of 2010), AMS Fellow (Inaugural Class 2013), AAAS Fellow (2012), and AWM Fellow (2020).
Currently she serves as Managing Editor of Mathematics of Computation. She also serves on the editorial boards of the SIAM Journal on Numerical Analysis, Numerische Mathematik, Numerical Algorithms, Electronic Transactions on Numerical Analysis, the Journal of Numerical Mathematics, and Computational Methods in Applied Mathematics. Dr. Brenner is also the Editor-in-Chief of the SIAM Classics in Applied Mathematics book series, all while serving on the the SIAM and AMS Councils.
Research interests include: numerical analysis, scientific computing, finite element methods, multigrid and domain decomposition methods, computational mechanics, computational electromagnetics, variational inequalities, and PDE constrained optimization.

Marta D'Elia, Pasteur Labs

Time: Saturday (11/4) 08:30 am - 09:30 am
Venue: Griffin 147
Title: Scientific Machine Learning in Industrial Pipelines: Methods and Examples

Abstract: Scientific machine learning (SciML) has shown great promise in the context of accelerating classical physics solvers and discovering new governing laws for complex physical systems. However, while the SciML activity in foundational research is growing exponentially, it lags in real-world utility, including the reliable and scalable integration into industrial pipelines. SciML algorithms need to advance in maturity and validation, which in the context of traditional and advanced industrial settings, requires operating in cyber-physical environments marked by large-scale, three-dimensional, streaming data that is confounded with noise, sparsity, irregularities and other complexities that are common with machines and sensors interacting with the real, physical world. In this talk, I will highlight some of the current challenges in applying SciML in industrial contexts. By using a practical example, the heat exchanger simulation and design, I will discuss why these are necessary bottlenecks to break through and describe possible strategies. Special attention will be on the generation of fast and flexible surrogates for flow and heat exchange problems with emphasis on graph-based Neural Operators and Gaussian processes.

Dr. Marta D'Elia earned a Ph.D. in applied mathematics at Emory University, 2011. She is a Principal Scientist at Pasteur Labs and an Adjunct Professor at Stanford ICME. Previously, she was a Research Scientist at Meta and a Principal Member of the Technical Staff at Sandia National Laboratories, California. Dr. D'Elia's work deals with Scientific Machine Learning, Optimization and Optimal Design, and Nonlocal and Fractional Problems.

Robert Kirby, Baylor University

Time: Friday (11/3) 05:15 pm - 06:15 pm
Venue: Griffin 147
Title: High-level Software for Numerical PDE

Abstract: FORTRAN was originally a radical and subversive proposal. Writing raw binary code was the “only way” to achieve good performance on early computers. A computer program that would translate formulas into binary met widespread opposition of the form 1) it cant be done 2) If it can be done it will waste computer resources and 3) even if it works, “real” programmers wont use it. This refrain was repeated at the introduction of MATLAB, the adoption of Python and other scripting languages, and the development of domain-specific languages and libraries for highly specialized fields such as partial differential equations. Despite the headwinds, the last few decades have seen the development of high-level, robust, and efficient software tools for numerical PDE These tools, such as Deal.II, FEniCS, and Firedrake, expedite the implementation of finite element methods, allowing users to deploy complex, accurate simulations in relatively compact, high-level code code. In this talk, I hope to discuss three major themes: i) Survey the historical development and challenges these projects have faced ii) Explore how different design decisions taken affect the user and developer experiences, especially contrasting a “bottom-up” approach via library development (e.g. Deal.II) with a “top-down” approach of domain-specific languages (e.g. FEniCS/Firedrake) and iii) how there is great value-added for composing such tools with “outer loop” simulation.

Dr Kirby earned a Ph.D. from the University of Texas at Austin, 2000 and is Professor of Mathematics at Baylor University.
Dr. Kirby’s work focuses on finite elements for partial differential equations, preconditioners for multiphysics problems, mathematical software, multicore computing.

Maxim A. Olshanskii, University of Houston

Time: Sunday (11/5) 08:30 am - 09:30 am
Venue: Griffin 147
Title: Unfitted Finite Element Methods for PDEs Posed on Surfaces

Abstract: Partial differential equations posed on surfaces arise in mathematical models for many natural phenomena, such as diffusion along grain boundaries, lipid interactions in biomembranes, pattern formation, and the transport of surfactants on fluidic interfaces, to name a few. Numerical methods for solving PDEs posed on manifolds have recently received considerable attention. In this presentation, we will discuss finite element methods for solving PDEs on both stationary surfaces and surfaces with prescribed evolution. The focus of this discussion is on geometrically unfitted methodsmethods that circumvent the need for surface parametrization and triangulation in a conventional sense. We will elucidate how these unfitted discretizations facilitate the development of a fully Eulerian numerical framework and enable easy handling of time-dependent surfaces, including scenarios involving topological transitions.

Dr. Olshanskii received his Ph.D. degree from Moscow State University in 1996 and a second doctorate (Habilitation) in Mathematics from the Institute of Numerical Mathematics, Russian Academy of Science in 2006. He is currently a professor of Mathematics at the University of Houston. He also holds an adjunct professorship at Emory University. Until 2012, he was a professor at the Department of Mathematics and Mechanics at Moscow State University.
His research interests lie in numerical analysis and scientific computing, with a focus on applications to fluid problems, interface and free boundary problems, geometric PDEs, reduced order modeling, and cardiovascular models. He has been recognized with research awards from multiple agencies in the USA, Russia, and the European Union.
Dr. Olshanskii serves as the Editor in Chief of the Journal of Numerical Mathematics and is a member of the editorial boards of the journals Computational Methods in Applied Mathematics and European Journal of Mathematics.

Abstracts of Mini-Symposium Presentations

MS01: Recent Developments and Applications of High-fidelity Numerical Simulations for Fluid Flows

Organizers: Yong Yang (West Texas A&M University) and Yonghua Yan (Jackson State University)
Time: Saturday (11/4) 09:45 am - 11:45 am
Venue: Griffin 129

B2.1 Time: Saturday (11/4) 09:45 am - 10:15 am

Title: Evaluating Modern High-Resolution WENO Schemes for Supersonic Flow Simulations

Presenter: Shiming Yuan

Affiliation: Jackson State University, Jackson, Mississippi, USA

Abstract: Numerical schemes based on the weighted essentially non-oscillatory (WENO) method are critical tools for simulating complex supersonic fluid flows. This study compared the behavior of the Modified Weighted Compact Scheme at different configurations - against the standard 5th order WENO. The governing equations for supersonic flow were solved using each scheme to explore resolution capabilities. The Modified Weighted Compact Scheme demonstrated superior resolution over the classic WENO. We also evaluated the schemes under different flux splitting approaches. The Modified Weighted Compact Scheme showed the least deviation, indicating robustness across numerical formats. However, the Modified Weighted Compact Scheme exhibited poorer numerical stability compared to the standard WENO schemes, especially about boundary condition sensitivity. The standard WENO provided a more stable solution, likely due to its optimized smoothing functions. While the Modified Weighted Compact Scheme offers exceptional resolution, its instability warrants caution. The 5th order WENO remains a reliable option combining good resolution with numerical stability. Further work is needed to develop schemes that achieve both high resolution and robustness for supersonic applications.

Authors: Shiming Yuan (Jackson State University) and Caixia Chen (Tougaloo College)

B2.2 Time: Saturday (11/4) 10:15 am - 10:45 am

Title: Investigating Vortex Interactions in Tandem Micro Vortex Generator Arrangements for Supersonic Flow Control

Presenter: Yonghua Yan

Affiliation: Jackson State University, Jackson, Mississippi, USA

Abstract: Supersonic flows present unique challenges due to shockwave-boundary layer interactions that can cause severe flow separation and instability. Micro vortex generators (MVGs) have emerged as a promising passive flow control approach to mitigate these effects. MVGs are small, thin devices that generate streamwise and spanwise vortices. The vortices mix high-momentum flow into the boundary layer, providing sufficient energy to overcome adverse pressure gradients and enable the flow to resist separation. Though prior studies established the shockwave control benefits of isolated MVGs, practical implementations often arrange multiple MVGs as an array to maximize coverage and system performance. The complex aerodynamic interactions between vortices shed from neighboring MVGs remain poorly understood. This knowledge gap hinders the optimization of MVG configurations tailored for specific supersonic flow control objectives. Using high-fidelity numerical

simulations, this work provides unprecedented insights into the physics of two MVGs arranged in tandem under varying inflow conditions. The details of the tandem MVG flows are characterized and analyzed in three dimensions. The results reveal that the vortices from each MVG strongly interact and merge further downstream. Specifically, the vortex structures influenced and altered one another's development. The momentum deficit after the second MVG did not strengthen significantly. In terms of overall vortex strength, the tandem vortex structures exhibited a canceling effect, limiting boundary layer control authority. This study finds that a simple tandem MVG arrangement may not strengthen vortices or enhance boundary layer control compared to an isolated MVG. The complex aerodynamic coupling between neighboring MVGs must be considered in optimizing multi-MVG configurations for supersonic flow control.

Authors: Yonghua Yan (Jackson State University), Yong Yang (West Texas A&M University), and Demetric L. Baines (Jackson State University)

B2.3 Time: Saturday (11/4) 10:45 am - 11:15 am

Title: Advancements in 3D High-Density Ratio Two-Phase Lattice Boltzmann Method for Capturing Complex Fluid Dynamics

Presenter: Yong Yang

Affiliation: West Texas A&M University, Canyon, Texas, USA

Abstract: In this research endeavor, we present significant enhancements to a high-density ratio two-phase lattice Boltzmann method (LBM), focusing on its application in three-dimensional simulations. Our work extends the capabilities of this method, enabling the accurate representation of intricate fluid phenomena, such as the collision of two droplets and a droplet impinging onto a thin film. Leveraging the unique characteristics of the LBM, which selectively calculates only within the fluid phase, our approach offers notable advantages in computational efficiency while providing detailed insights into complex fluid dynamics. Highlights of this method include (a) computational costs reduction compared to traditional fluid simulation approaches due to exclusively simulating within the fluid phase, (b) applicability in scenarios with extreme density disparities, such as the 1000:1 density ratio, (c) accurate capture of the movement of phase interfaces using a method based on the ratio between mass and density of the interface lattice. This method finds applications across various fields, including biophysics and engineering, where a precise understanding of fluid behavior is crucial for optimizing processes and making informed decisions.

Authors: Yong Yang (West Texas A&M University), Yonghua Yan (Jackson State University), and Caixia Chen (Tougaloo College)

B2.4 Time: Saturday (11/4) 11:15 am - 11:45 am

Title: Simulation of Rarefied Hypersonic Gas Flow Using Alexeev Generalized Hydrodynamic Equations

Presenter: Alex Fedoseyev

Affiliation: Ultra Quantum Inc., Huntsville, Alabama, USA

Abstract: Generalized Hydrodynamic Equations (GHE) by Boris Alexeev (1994, 2004) have been derived from the Generalized Boltzmann Equation (GBE) that was obtained by the first principles from the chain of Bogolubov kinetic equations. The GHE model is supposed to account for kinetic effects (intermediate Knudsen number, fluctuations) in the continuum approximation. Simulations of hypersonic flows is a very challenging problem as those can exhibit both continuum and non continuum flow regimes. Typically, the flow can be continuous to transitional in the near field flow

structure, and free molecular flow in the far field. The bow shock can be detached from the vehicle at high-altitude, and near boundary slip-flow is typical for such regimes. First results of GHE model for hypersonic flows have been reported in Fedoseyev (2020), Fedoseyev and Griaznov (2021). In this paper we continue a comparison of simulation results of our GHE model with the experimental data for rarefied hypersonic flows by Allegre et al. (1997) and several other works. Simulations by Direct Simulation Monte Carlo (DSMC) method are provided for comparisons. The comparisons show good agreements of both GHE and DSMC with the experiment, or each other, confirming that GHE model can be used for simulation of hypersonic rarefied flows.

Authors: Alex Fedoseyev (Ultra Quantum Inc.)

MS02: Accurate, robust, and structure-preserving methods for computational fluid dynamics

Organizers: Jesse Chan (Rice University) and Matthias Maier (Texas A&M) and Ignacio Tomas (Texas Tech)
Time: Friday (11/3) 03:00 pm - 05:00 pm, Saturday (11/4) 09:45 am - 11:45 am, Saturday (11/4) 01:30 pm - 03:30 pm
Venue: Griffin 301

B1.1 Time: Friday (11/3) 03:00 pm - 03:30 pm

Title: Efficient Numerical Schemes for the **Q**-Tensor Model of Nematic Liquid Crystals

Presenter: Justin Swain

Affiliation: University of North Texas

Abstract: In this presentation, I will talk about computational modeling of nematic liquid crystals, specifically focusing on building linear numerical methods using the Landau deGennes **Q**-tensor theory. This nonlinear second order PDE uses a symmetric second order tensor **Q** as the order parameter which describes the local average orientation of nematic liquid crystal molecules. The emphasis will be on the development and analysis of three numerical schemes. First, I will introduce a linear, decoupled, and first-order accurate scheme that is unconditionally energy stable by using a truncation of the nonlinear thermotropic potential function. Next, I will present a linear, coupled, and second-order accurate numerical scheme which gives higher accuracy at the price of computational time and energy stability. Lastly, I will change some aspects of the first approach, still retaining linearity, decoupling, and maintaining first-order accuracy, however, this scheme is not unconditionally energy stable but promises significantly reduced numerical dissipation and computational cost. Throughout the presentation, I will showcase simulation results to validate these schemes and offer a comparative analysis of their efficiency, convergence rates, and numerical dissipation.

Authors: Justin Swain (University of North Texas) and Giordano Tierra (University of North Texas)

B1.2 Time: Friday (11/3) 03:30 pm - 04:00 pm

Title: Limiting techniques for high order, entropy stable, and positivity-preserving discontinuous Galerkin discretizations

Presenter: Yimin Lin

Affiliation: Rice University

Abstract: High-order accuracy, entropy stability, and positivity preservation are crucial properties for numerical discretizations used to solve the compressible Euler and Navier-Stokes equations. However, achieving all of these properties simultaneously is nontrivial. In this work, we discuss two limiting strategies that can achieve all three properties. First, we introduce a positivity limiting strategy for entropy-stable discontinuous Galerkin discretizations based on high order DG (discontinuous Galerkin) positivity-preserving limiter. The key ingredient in the limiting procedure is a low order positivity-preserving discretization based on graph viscosity terms. The proposed limiter preserves the positivity of thermodynamics quantities in the presence of the viscous term in the compressible Navier-Stokes equation. Next, we propose a subcell limiting strategy of the DG spectral element discretization (DGSEM) that satisfies the semi-discrete cell entropy inequality and the positivity constraint by formulating the limiting factors as solutions to an optimization problem. The optimization problem is efficiently solved using a deterministic greedy algorithm. Common subcell limiting strategies cannot retain high order accuracy and entropy stability at the same time. The proposed limiting strategies are both high-order accurate, positivity-preserving, and ensure semi-discrete entropy stability for the compressible Euler and Navier-Stokes equations. We illustrate the behavior of the methods using both analytical solutions and model problems such as the Daru-Tenaud shock tube and hypersonic astrophysical jet.

Authors: Yimin Lin (Rice University), Jesse Chan (Rice University), and Ignacio Tomas (Texas Tech University)

B1.3 Time: Friday (11/3) 04:00 pm - 04:30 pm

Title: Positivity-preserving time discretizations for production-destruction equations with applications to non-equilibrium flows

Presenter: Juntao Huang

Affiliation: Texas Tech University

Abstract: In this presentation, we introduce a novel family of second and third-order Modified Patankar Runge-Kutta (MPRK) methods designed to address production-destruction equations. These methods are both conservative and unconditionally positivity-preserving, meaning the time step size is independent of the stiffness of reaction terms. We rigorously establish the necessary and sufficient conditions for achieving the intended order of accuracy. Extending this ordinary differential equation solver, we adapt it for semi-discrete schemes to solve multi-species Euler equations with chemical reactions. By synergizing this time integration approach with positivity-preserving finite difference Weighted Essentially Non-Oscillatory (WENO) schemes, we achieve a robust positivity-preserving WENO method applicable to non-equilibrium flows. The performance and effectiveness of these methods are validated through a variety of numerical tests.

Authors: Juntao Huang (Texas Tech University), Weifeng Zhao (University of Science and Technology Beijing), and Chi-Wang Shu (Brown University)

B1.4 Time: Friday (11/3) 04:30 pm - 05:00 pm

Title: Semi-implicit projection methods for incompressible flows with variable density coupled with the temperature equation

Presenter: An Vu

Affiliation: University of Houston

Abstract: We present a semi-implicit approach for approximating the incompressible Navier-Stokes equations with variable density and viscosity. This method incorporates a projection technique to ensure flow incompressibility, and uses momentum, defined as the product of density and velocity, as a dependent variable. We demonstrate the scheme's stability and establish first-order error estimates. Furthermore, our investigation extends to include the temperature equation, where we explore a time-marching multiphase thermal solver and study its stability and error estimates. We propose a fully discretized algorithm employing finite element methods, and we verify its convergence properties through numerical simulations on a variety of problems involving significant density ratios.

Authors: An Vu (University of Houston) and Loic Cappanera (University of Houston)

B2.1 Time: Saturday (11/4) 09:45 am - 10:15 am

Title: A learned conservative semi-Lagrangian finite volume scheme for transport simulations

Presenter: Wei Guo

Affiliation: Texas Tech University

Abstract: Semi-Lagrangian (SL) schemes are known as a major numerical tool for solving transport equations with many advantages and have been widely deployed in the fields of computational fluid dynamics, plasma physics modeling, numerical weather prediction, among others. In this work, we develop a novel machine learning-assisted approach to accelerate the conventional SL finite volume (FV) schemes. The proposed scheme avoids the expensive tracking of upstream cells but attempts to learn the SL discretization from the data by incorporating specific inductive biases in the neural network, significantly simplifying the algorithm implementation and leading to improved efficiency. In addition, the method delivers sharp shock transitions and a level of accuracy that would typically require a much finer grid with traditional transport solvers. Numerical tests demonstrate the effectiveness and efficiency of the proposed method.

Authors: Yongsheng Chen (Zhejiang University) and Xinghui Zhong (Zhejiang University)

B2.2 Time: Saturday (11/4) 10:15 am - 10:45 am

Title: Convergence of a pressure-robust space-time hybridized discontinuous Galerkin method for incompressible flows

Presenter: Keegan Kirk

Affiliation: Rice University

Abstract: Much recent interest in the numerical solution of incompressible flow problems has concentrated on pressure-robust finite element methods, a class of mixed methods that preserve a fundamental invariance property of the incompressible Navier-Stokes equations. The violation of this invariance property at the discrete level manifests in a pressure-dependent consistency error that can pollute the velocity error. Two key ingredients are required for pressure-robustness: exact enforcement of the incompressibility constraint, and H(div)-conformity of the finite element solution. This talk will discuss a space-time hybridized discontinuous Galerkin finite element method for the evolutionary incompressible Navier-Stokes equations. The numerical scheme has a number of desirable properties, including pointwise mass conservation, energy stability, and high-order accuracy in both space and time. Through the introduction of a pressure facet variable, H(div)-conformity of the discrete velocity solution is enforced, ensuring the numerical scheme is pressure-robust. A priori error estimates for smooth solutions will be presented, as well as convergence to weak solutions in the sense of Leray and Hopf using compactness results for broken polynomial spaces.

Authors: Keegan Kirk (Rice University), Tamas Horvath (Oakland University), Sander Rhebergen (University of Waterloo), and Aycil Cesmelioglu (Oakland University)

B2.3 Time: Saturday (11/4) 10:45 am - 11:15 am

Title: Invariant-domain preserving and involution preserving IMEX schemes for magneto-hydrodynamics

Presenter: Jean-Luc Guermond

Affiliation: Department of Mathematics, Texas A&M University, College Station, TX 77843

Abstract: I will discuss recent approximation results regarding the approximation of Maxwell's equations written in first-order form. I will show in particular that the discontinuous Galerkin approximation is spectrally correct. This result is based on the observation that the discontinuous Galerkin approximation preserves a fundamental involution property which is known as Gauss's law in the literature. A similar result is conjectured to hold true for stabilized continuous finite elements. I will also present a numerical technique for solving the ideal MHD equations that is invariant-domain preserving and involution preserving. The key novelty is that no divergence cleaning is needed. The method will be numerically illustrated using continuous finite elements. The first part of this project is a joint work with Alexandre Ern (ENPC, Paris). The second part of this project is a joint work with Tuan Anh Dao (Uppsala University) and Ignacio Tomas (Texas Tech University).

Authors: Jean-Luc Guermond (Texas A&M University)

B2.4 Time: Saturday (11/4) 11:15 am - 11:45 am

Title: Online Bayesian Optimization of Polynomial-Multigrid Cycles for Flux Reconstruction

Presenter: Sambit Mishra

Affiliation: Texas A&M University

Abstract: We introduce an innovative approach to optimise polynomial multigrid cycles to enhance convergence acceleration of incompressible flow simulations. To achieve this, we apply the Bayesian Optimisation approach to efficiently sample possible cycles to minimise runtime. To allow the use of traditional optimisation methods, we developed fractional smoothing steps for multigrid cycles to perform optimisation in a continuous domain. Initially we explored a static *offline* optimisation strategy and identified optimal cycles. However the performance of the cycles was not transferable across different simulations. This observation led us to develop a dynamic *online* optimisation strategy where cycles are continuously optimised with simulation progress. The performance of the optimal cycles determined through this approach gave similar speed up to the offline approach, with the added advantage of continuous progression during the simulation. Tests were performed on three case setups of flow past cylinder at Reynolds numbers 200, 500 and 3900 to give speedups of about 3.0×, 2.1× and 1.9× respectively.

Authors: Sambit Mishra (Texas A&M University), Will Trojak (Texas A&M University), and Freddie Witherden (Texas A&M University)

B3.1 Time: Saturday (11/4) 01:30 pm - 02:00 pm

Title: Towards an involution-preserving solver for the time-dependent Maxwell equations

Presenter: Jordan Hoffart

Affiliation: Texas A&M University

Abstract: We present an involution-preserving and spectrally correct nodal discontinuous Galerkin method for the eigenvalue problem related to Maxwell's equations written in first-order form. The numerical scheme is implemented with the deal.II finite element library and tested on various domains that admit both singular and non-singular eigenmodes. This is a first step in a larger effort to develop an involution-preserving finite element solver for the time-dependent Maxwell equations.

Authors: Jean-Luc Guermond (Texas A&M University), Jordan Hoffart (Texas A&M University), Matthias Maier (Texas A&M University)

B3.2 Time: Saturday (11/4) 02:00 pm - 02:30 pm

Title: Structure-preserving finite-element schemes for the Euler-Poisson equations

Presenter: Matthias Maier

Affiliation: Texas A&M University

Abstract: We discuss structure-preserving numerical discretizations for the repulsive and attractive Euler-Poisson equations. The scheme is fully discrete and structure preserving in the sense that it maintains a discrete energy law, as well as hyperbolic invariant domain properties, such as positivity of the density and a minimum principle of the specific entropy. We discuss the underlying algebraic discretization technique based on collocation and convex limiting that maintain hyperbolic invariants and a discrete energy law, and discuss recovery strategies to maintain the discrete Gauss law.

Authors: Matthias Maier (Texas A&M University) and Ignacio Tomas (Texas Tech University)

B3.3 Time: Saturday (11/4) 02:30 pm - 03:00 pm

Title: Invariant Domain Preserving and Exactly Conservative Approximation of the Lagrangian Hydrodynamics Equations

Presenter: Madison Sheridan

Affiliation: Texas A&M University

Abstract: The numerical approximation of the Euler equations in a Lagrangian frame is motivated by many multiphysics scenarios such as materials undergoing very large deformations in localized regions. Lagrangian methods excel in tracking interfaces between materials. In this talk we present a first order finite element method for approximating the compressible Euler equations in Lagrangian coordinates. This method is explicit in time, uses a discontinuous Galerkin finite element approximation of the conservative variables with continuous quadratic elements for the motion of the mesh, is exactly mass conservative (in the Lagrangian sense), is invariant-domain preserving, and can be used with an arbitrary or tabulated equation of state.

Authors: Jean-Luc Guermond (Texas A&M University) and Madison Sheridan (Texas A&M University)

B3.4 Time: Saturday (11/4) 03:00 pm - 03:30 pm

Title: Asymptotic-preserving and invariant-preserving schemes for hyperbolic conservation laws with stiff reaction source term

Presenter: Zuodong Wang

Affiliation: Ecole des Ponts ParisTech, France

Abstract: We propose and analyze a new framework for asymptotic-preserving and invariant-preserving schemes with a stiff reaction source term. We will focus on the prototype model proposed by R. J. LeVeque. It is the first time that asymptotic-preserving property is satisfied for a multi-dimensional setting in this model in the literature. The compensated compactness theorem is applied to prove convergence, and numerical tests confirm the effectiveness of our method.

Authors: Alexandre Ern (Ecole des Ponts ParisTech), Jean-Luc Guermond (Texas A&M University), and Zuodong Wang (Ecole des Ponts ParisTech)

MS03: Recent Developments in Mathematical and Numerical Analysis of Partial Differential Equations and Their Applications

Organizers: Yangwen Zhang (University of Louisiana at Lafayette)
Time: Saturday (11/4) 01:30 pm - 03:30 pm, Saturday (11/4) 03:45 pm - 04:45 pm, Sunday (11/5) 09:45 am - 10:45 am, Sunday (11/5) 11:00 am - 01:00 pm
Venue: Griffin 302

B3.1 Time: Saturday (11/4) 01:30 pm - 02:00 pm

Title: On convergence analysis of an IEQ-based numerical scheme for hydrodynamical Q-tensor model

Presenter: Yukun Yue

Affiliation: University of Wisconsin-Madison

Abstract: This talk will focus on a numerical approach based on the Invariant Quadratization Method(IEQ) to find solutions for a hydrodynamical system. We start with a toy model concerned with the parabolic type Q-tensor equations, numerical design schemes that keep energy dissipation law discretely, and analyze its properties. Then we present a convergence analysis of an unconditional energy-stable first-order semi-discrete numerical method intended for the hydrodynamic Q-tensor model. This model couples a Navier-Stokes system for the fluid flows and a parabolic type Q-tensor system governing the nematic liquid crystal director fields. We prove the stability properties of the scheme and show convergence to weak solutions of the coupled fluid crystal system. We will also be able to give you a brief overview of recent results on the existence and regularity of Beris-Edwards systems and other related models.

Authors: Yukun Yue (University of Wisconsin-Madison)

B3.2 Time: Saturday (11/4) 02:00 pm - 02:30 pm

Title: Modeling and Numerical Analysis of the Cholesteric Landau–de Gennes model

Presenter: Andrew Hicks

Affiliation: Louisiana State University

Abstract: Liquid Crystals (LCs) are a key component of our life in the modern world, appearing in various technologies, such as LC displays and temperature sensors. We investigate the numerical analysis of the Landau–de Gennes (LdG) model, which utilizes a 3x3 symmetric tensor as the order parameter (the "Q-tensor"). This model is usually preferred over others, such as the Oseen-Frank model, which we briefly review. We also show how the standard LdG model can be extended to model cholesteric LCs, which have applications in droplet lasers, novel bio-sensors, and anti-counterfeiting markers. Next, we describe a finite element discretization of the model and an L^2 gradient flow scheme for computing local minimizers, and we discuss various time-step restrictions for the gradient flow scheme to be energy decreasing. Furthermore, we prove a mesh size restriction that is critical for avoiding spurious numerical artifacts in the numerical solutions, which is not well-known in the LC literature, particularly when simulating cholesteric LCs that exhibit "twist". Finally, we present various numerical simulations in 3-D, on both slab geometries and spherical shells, and connect these results with experiments.

Authors: Andrew Hicks (Louisiana State University) and Shawn W. Walker (Louisiana State University)

B3.3 Time: Saturday (11/4) 02:30 pm - 03:00 pm

Title: Computational Methods for Scattering Resonances

Presenter: Jiguang Sun

Affiliation: Michigan Technological University

Abstract: Computational Methods for Scattering Resonances Abstract: Scattering resonances have important applications in mathematics, physics and engineering. They can be viewed as the poles of the meromorphic extension of the scattering operator. In this talk, we consider the computation of the scattering poles for sound soft obstacles. The scattering problem is formulated using boundary integrals, which is then discretized by the Nystrom method. The discrete scattering poles are computed using a multistep contour integral method. The proposed method is highly accurate, free of spurious modes, and can be extended to treat other obstacles, e.g., sound hard obstacles. Numerical examples are presented to validate the effectiveness and accuracy.

Authors: Jiguang Sun (Michigan Technological University)

B3.4 Time: Saturday (11/4) 03:00 pm - 03:30 pm

Title: Exponential Integrators and the Polynomial Time Integration Framework

Presenter: Tommaso Buvoli

Affiliation: Tulane University

Abstract: Exponential integrators are a class of time integration methods that treat a linear component exactly while approximating all the remaining terms explicitly. These methods have proven highly efficient for solving stiff ordinary differential equations and can outperform competing approaches such as Rosenbrock and implicit-explicit methods. In this talk, I will discuss how a new time integration framework based on polynomial interpolation can be used to construct high-order, parallelizable exponential integrators. This polynomial time integration framework simplifies the construction of efficient, multivalued time integration methods by utilizing continuous polynomials in time to approximate the ODE solution. I will discuss the stability of the new polynomial methods, present several numerical experiments, and broadly highlight the benefits and challenges of exponential integrators applied to stiff systems.

Authors: Tommaso Buvoli (Tulane University)

B4.1 Time: Saturday (11/4) 03:45 pm - 04:15 pm

Title: Sign-preserving second-order IMPEC time discretization

Presenter: Yang Yang

Affiliation: Michigan Technological University

Abstract: In this talk, we construct sign-preserving second-order IMplicit Pressure Explicit Concentration (IMPEC) time methods for generalized coupled non-Darcy flow and transport problems in petroleum engineering. We use interior penalty discontinuous Galerkin (IPDG) methods for spatial discretization, and develop bound-preserving techniques to obtain physically relevant numerical approximations. The method is based on the framework of the second-order strong-stability-preserving Runge-Kutta (SSP-RK2) method. The basic idea is to treat the pressure equation implicitly and the concentration equation explicitly so as to obtain a first-order time integration. Then we introduce a correction stage to compensate for the accuracy, maintaining the physical bounds of the numerical cell averages. The proposed method yields a much larger CFL number compared with first-order IMPEC schemes. Moreover, the effectiveness of the bound-preserving technique will also be verified.

Authors: Wenjing Feng (China University of Petroleum) and Hui Guo (China University of Petroleum)

B4.2 Time: Saturday (11/4) 04:15 pm - 04:45 pm

Title: A New Practical Framework for the Stability Analysis of Perturbed Saddle-point Problems and Applications

Presenter: Qingguo Hong

Affiliation: Missouri S&T

Abstract: This talk provides a new abstract stability result for perturbed saddle-point problems which is based on a proper norm fitting. We derive the stability condition according to Bauska's theory from a small inf-sup condition, similar to the famous Ladyzhenskaya-Bauska-Brezzi (LBB) condition, and the other standard assumptions in Brezzi's theory under the resulting combined norm. The proposed framework allows to split the norms into proper seminorms and not only results in simpler (shorter) proofs of many stability results but also guides the construction of parameter robust norm-equivalent preconditioners. These benefits are demonstrated with several examples arising from different formulations of Biot's model of consolidation.

Authors: Qingguo Hong (Missouri S&T)

B4.3 Time: Sunday (11/5) 09:45 am - 10:15 am

Title: A scalar auxiliary variable unfitted FEM for the surface Cahn-Hilliard equation

Presenter: Yerbol Palzhanov

Affiliation: University of Houston

Abstract: We present a scalar auxiliary variable (SAV) method to solve the Cahn-Hilliard equation with degenerate mobility posed on a smooth closed surface Γ. The SAV formulation is combined with adaptive time stepping and a geometrically unfitted trace finite element method (TraceFEM), which embeds Γ in R3. The stability is proven to hold in an appropriate sense for both first- and second-order in time variants of the method. The performance of our SAV method is illustrated through a series of numerical experiments, which include systematic comparison with a stabilized semi-explicit method.

Authors: Yerbol Palzhanov (University of Houston)

B4.4 Time: Sunday (11/5) 10:15 am - 10:45 am

Title: Variational Problems in Measure Spaces with Regular Divergences and Mixed Boundary Conditions

Presenter: Carlos Nicolas Rautenberg

Affiliation: George Mason University

Abstract: We consider a class of variational problems involving partial differential operators on non-standard vector-valued measure spaces with divergences (represented by measures or by functions) and mixed boundary conditions. The class of problems arise via duality of an associated sandpile accumulation model featuring gradient constraints. The boundary conditions for the state variable are established by means of a normal trace characterization of the vectorial measure. The latter further allows to define subspaces of measures that directionally vanish in parts of the boundary. We finalize the talk (if time permits) with numerical tests.

Authors: Carlos Nicolas Rautenberg (George Mason University)

B5.1 Time: Sunday (11/5) 11:00 am - 11:30 am

Title: Computing the Shape Operator with the HHJ Method

Presenter: Shawn W. Walker

Affiliation: Louisiana State University

Abstract: This talk shows how the classic Hellan–Herrmann–Johnson (HHJ) method can be extended to surfaces for computing curvature. We start by showing how HHJ can be extended to surfaces embedded in $\mathbb{R}^3$ to solve the surface version of the Kirchhoff plate equation. The surface Hessian of the "displacement" variable is discretized by an HHJ finite element function. Convergence is established for all possible combinations of mixed boundary conditions, e.g. clamped, simply-supported, free, and the "4th" condition. Numerical examples are shown, some which use "point" boundary conditions as well as solving the surface biharmonic equation. We also show how the surface HHJ method can be used to post-process a discrete Lagrange function on a given surface triangulation to yield an approximation of its surface Hessian, which can be viewed as a kind of Hessian recovery. Moreover, we demonstrate that this scheme can be used to give convergent approximations of the *full shape operator* of the underlying surface using only the known discrete surface, even for piecewise linear triangulations. Several numerical examples are given on non-trivial surfaces that demonstrate the scheme.

Authors: Shawn Walker (Louisiana State University)

B5.2 Time: Sunday (11/5) 11:30 am - 12:00 pm

Title: Nodal finite element methods for the surface Stokes problem

Presenter: Alan Demlow

Affiliation: Texas A&M University

Abstract: Finite element discretization of the Stokes system posed on surfaces presents some difficulties not encountered in the Euclidean context. A particular challenge arises from the need to impose both tangentiality and continuity (H1-conformity) of the velocity vector field. It is not possible to satisfy both of these constraints exactly in a typical surface finite element setting, so most existing methods have enforced one or the other weakly by penalization. In this talk we present a method for the surface Stokes system which is based on the MINI element. Our method yields exactly tangential velocity fields. Our method yields H1-nonconforming elements, but in contrast to previous methods no penalization is required. The key step is the construction of nodal degrees of freedom. Our technique applies to other nodal Stokes elements such as Taylor-Hood, which we demonstrate computationally. This is joint work with Michael Neilan.

Authors: Alan Demlow (University of Louisiana at Lafayette) and Michael Neilan (University of Pittsburgh)

B5.3 Time: Sunday (11/5) 12:00 pm - 12:30 pm

Title: An Eulerian finite element method for tangential Navier-Stokes equations on evolving surfaces

Presenter: Paul Schwering

Affiliation: Institut für Geometrie und Praktische Mathematik, RWTH Aachen University

Abstract: The motion of an inextensible viscous fluid layer represented by a material surface can be described by the evolving surface Navier-Stokes equations. We introduce a method for the numerical solution of a simplified problem consisting of tangential surface Navier-Stokes equations (TSNSE) posed on a passively evolving smooth closed surface embedded in $\mathbb{R}^3$. For discretization of

the TSNSE, we consider a geometrically unfitted finite element method known as TraceFEM. The TraceFEM applies to a fully Eulerian formulation of the problem and does not require a surface triangulation, which makes it convenient for deforming surfaces. In TraceFEM, one uses standard (bulk) finite element spaces to approximate unknown quantities on the surface $\Gamma(t)$ which propagates through a given triangulation of an ambient volume Ω, i.e. $\Gamma(t) \subset \Omega$ for all times t. The discrete formulation does not need a surface parametrization and uses tangential calculus in the embedding space $\mathbb{R}^3$. For scalar PDEs on evolving surfaces, variants of TraceFEM are known in the literature e.g. in [2]. For the TSNSE we choose a hybrid (finite difference in time - finite elements in space) approach since it is more flexible in terms of implementation and the choice of elements. We use a BDF scheme for the time-discretization and a stable Taylor-Hood pair of finite elements in space. To represent the surface, we use a level-set description and a higher-order method to calculate integrals on the surface approximation. Theoretical results from [1] show the optimal order of convergence. In this presentation, we explain the method and present numerical experiments that illustrate the optimality of the convergence. References [1] Maxim A. Olshanskii, Arnold Reusken, and Paul Schwering (2023). An Eulerian finite element method for tangential Navier-Stokes equations on evolving surfaces. arXiv:2302.00779 [2] C. Lehrenfeld, M. A. Olshanskii, and X. Xu (2018). A stabilized trace finite element method for partial differential equations on evolving surfaces. SIAM Journal on Numerical Analysis, 56, pp. 1643-1672.

Authors: Paul Schwering (Institut für Geometrie und Praktische Mathematik, RWTH Aachen University) and Maxim A. Olshanskii (University of Housto) and Arnold Reusken (Institut für Geometrie und Praktische Mathematik, RWTH Aachen University)

B5.4 Time: Sunday (11/5) 12:30 pm - 01:00 pm

Title: Hybridizable discontinuous Galerkin methods for coupled systems of porous/poroelastic media and free flow equations

Presenter: Jeonghun J. Lee

Affiliation: Baylor University

Abstract: In this work we present hybridizable discontinuous Galerkin (HDG) methods for the problems that Stokes/Navier-Stokes equations and porous/poroelastic equations are coupled with interface. In our HDG methods the compressibilities of fluid and poroelastic matrix, and the fluid mass in poroelastic domain are strongly conservative. For time-dependent Navier-Stokes equations on free fluid domain, we derive quantatitive conditions for well-posedness of time-dependent numerical solutions and proved the a priori error estimates.

Authors: Aycil Cesmelioglu (Oakland University) and Jeonghun J. Lee (Baylor University) and Sander Rhebergen (University of Waterloo)

MS04: Recent developments in electromagnetics and related eigenvalue problems

Organizers: Mansi Bezbaruah (Texas A&M University) and Jordan Hoffart (Texas A&M University)
Time: Friday (11/3) 03:00 pm - 05:00 pm, Saturday (11/4) 09:45 am - 11:45 am
Venue: Griffin 302

B1.1 Time: Friday (11/3) 03:00 pm - 03:30 pm

Title: Spectral theory for linear periodic DAEs arising in the electrodynamics of 1D photonic crystals

Presenter: Aaron Welters

Affiliation: Florida Institute of Technology

Abstract: For one-dimensional (1D) photonic crystals (PCs) with passive lossless non-dispersive media, Maxwell's equations for time-harmonic electromagnetic fields become, under separation of variables, linear periodic differential-algebraic equations (DAEs) in canonical form. In this talk, we discuss how the electrodynamics of 1D PCs is reduced to studying the spectral theory (with frequency as the spectral parameter) of the associated minimal and maximal differential-algebraic operators of these DAEs. Our recent results will be presented on the self-adjointness of the maximal operator and its eigenvalues. We use this eigenvalue problem to highlight the differences in the spectral theory of canonical DAEs vs ODEs.

Authors: Aaron Welters (Florida Institute of Technology) and Bader Alshammari (Arar, Saudi Arabia)

B1.2 Time: Friday (11/3) 03:30 pm - 04:00 pm

Title: Bloch Waves for Maxwell's Equations in High-Contrast Photonic Crystals

Presenter: Robert Viator Jr.

Affiliation: Denison University

Abstract: We investigate the Bloch spectrum of a 3-dimensional high-contrast photonic crystal. The Bloch eigenvalues, for fixed quasi-momentum, are expanded in a power series in the material contrast parameter in the high-contrast limit, together with a convergence radius, obtained by decomposing an appropriate vectorial Sobolev space into three mutually orthogonal curl-free subspaces. We also identify the limit spectrum in the periodic case. Time permitting, we will describe some geometries which admit this special power series representation of the Bloch eigenvalues

Authors: Abithi Adili (University of Massachusetts - Lowell), Silvia Jimenez (Colgate University), Robert Lipton (Louisiana State University), and Robert Viator Jr. (Denison University)

B1.3 Time: Friday (11/3) 04:00 pm - 04:30 pm

Title: Spectrum of the Neumann-Poincaré operator for thin doubly connected domains

Presenter: Stephen P. Shipman

Affiliation: Louisiana State University at Baton Rouge

Abstract: We analyze the spectrum of the Neumann-Poincaré (NP) operator for a doubly connected domain lying between two level curves defined by a conformal mapping, where the inner boundary of the domain is of general shape. The analysis relies on an infinite-matrix representation of the NP operator involving the Grunsky coefficients of the conformal mapping and an application of the Gershgorin circle theorem. As the thickness of the domain shrinks to zero, the spectrum of the doubly connected domain approaches the interval [-1/2,1/2] in the Hausdorff distance and the density of eigenvalues approaches that of a thin circular annulus.

Authors: Doosung Choi (LSU), Mikyoung Lim (KAIST), and Stephen P. Shipman (LSU)

B1.4 Time: Friday (11/3) 04:30 pm - 05:00 pm

Title: High-order approximation of dispersive PDEs

Presenter: Seth Gerberding

Affiliation: Texas A&M University

Abstract: We present results on high-order finite element methods for approximating dispersive PDEs. In particular, we present the theory for handling a third-order differential operator and how to approximate a time-evolution equation involving it. Finally, we show how to make the method high-order and give error tables demonstrating the high order convergence.

Authors: Seth Gerberding (Texas A&M University) and Jean-Luc Guermond (Texas A&M University)

B2.1 Time: Saturday (11/4) 09:45 am - 10:15 am

Title: Edge modes in several topological wave insulators

Presenter: Junshan Lin

Affiliation: Auburn University

Abstract: The development of the topological wave insulators was inspired by success of topological insulators in condensed matter physics. In this talk, I will present mathematical studies of the edges modes in several topological wave insulators, which can guide classical waves along the interface of two periodic structures with different topological phases. In particular, I will give the theory on the existence of the edge modes in these insulators.

Authors: Junshan Lin (Auburn University), Jiayu Qiu (Hong Kong University of Science and Technology), and Hai Zhang (Hong Kong University of Science and Technology)

B2.2 Time: Saturday (11/4) 10:15 am - 10:45 am

Title: Mathematical Models of Topologically Protected Transport in Electrically Gated Twisted Bilayer Graphene

Presenter: Daniel Massatt

Affiliation: Louisiana State University

Abstract: Twisted bilayer graphene gives rise to large moiré patterns that form a triangular network upon mechanical relaxation. If gating is included, each triangular region has gapped electronic Dirac points that behave as bulk topological insulators with topological indices depending on valley index and the type of stacking. Since each triangle has two oppositely charged valleys, they remain topologically trivial. In this work, we address several questions related to the edge currents of this system by analysis and computation of continuum PDE models. First, we derive the bulk invariants corresponding to a single valley, and then apply a bulk-interface correspondence to quantify asymmetric transport along the interface. Second, we introduce a valley-coupled continuum model to show how valleys are approximately decoupled in the presence of small perturbations using a multiscale expansion, and how valleys couple for larger defects. Third, we present a method to prove for a large class of continuum (pseudo)differential models that a quantized asymmetric current is preserved through a junction such as a triangular network vertex. We support all of these arguments with numerical simulations using spectral methods to compute relevant currents and wave packet propagation.

Authors: Guillaume Bal (University of Chicago), Paul Cazeaux (Virginia Tech), Daniel Massatt (Louisiana State University), and Solomon Quinn (University of Minnesota)

B2.3 Time: Saturday (11/4) 10:45 am - 11:15 am

Title: Scalable DPG Multigrid Solver for High-Frequency Helmholtz Problems

Presenter: Jacob Badger

Affiliation: University of Texas at Austin

Abstract: Scalable solution of time-harmonic high-frequency wave propagation problems—including acoustic Helmholtz, elastic Helmholtz, and time-harmonic Maxwell—remains an active area of inquiry. One challenge is that classical discretization techniques (e.g., Galerkin finite elements, finite difference, etc.) yield indefinite discrete systems that preclude use of many scalable solution algorithms. Significant progress has been made to develop specialized preconditioners for such indefinite systems, but general-purpose scalable wave propagation solvers remain elusive. A second approach instead uses minimum residual discretizations—that yield definite discrete systems—and may be amenable to more standard preconditioners such as multigrid methods. The discontinuous Petrov-Galerkin (DPG) finite element methodology is one such minimum residual method with additional properties including mesh-independent stability and a built-in error indicator. This talk details a hybrid MPI/OpenMP implementation of a multigrid preconditioner for general DPG systems discretized with the standard energy spaces–including high-frequency wave propagation problems. We emphasize that the DPG multigrid (DPG-MG) solver is applicable to general DPG systems and can thus be applied to acoustic Helmholtz, elastic Helmholtz, and time-harmonic Maxwell problems, as well as a variety of other problems, without modification. Scalable implementation reveals that the DPG-MG solver is highly competitive for high-frequency wave propagation problems in both pre-asymptotic and asymptotic regimes, enabling solution of high-frequency 3D wave propagation problems with $O(10^11)$ degrees of freedom in minutes.

Authors: Jacob Badger (University of Texas at Austin) and Leszek Demkowicz (University of Texas at Austin)

B2.4 Time: Saturday (11/4) 11:15 am - 11:45 am

Title: Shape optimization of optical microscale inclusions

Presenter: Manaswinee Bezbaruah

Affiliation: Texas A&M University

Abstract: We describe a class of shape optimization problems for optical metamaterials comprised of periodic microscale inclusions composed of a dielectric, low-dimensional material suspended in a non-magnetic bulk dielectric. The shape optimization approach is based on a homogenization theory for time-harmonic Maxwell's equations that describes effective material parameters for the propagation of electromagnetic waves through the metamaterial. The control parameter of the optimization is a deformation field representing the deviation of the microscale geometry from a reference configuration of the cell problem. This allows for describing the homogenized effective permittivity tensor as a function of the deformation field. We show that the underlying deformed cell problem is well-posed and regular. This, in turn, proves that the shape optimization problem is well-posed. In addition, a numerical scheme is formulated that utilizes an adjoint formulation with either gradient descent or BFGS as optimization algorithms. The developed algorithm is tested numerically on a number of prototypical shape optimization problems with a prescribed effective permittivity tensor as the target.

Authors: Manaswinee Bezbaruah (Texas A&M University), Matthias Maier (Texas A&M University), and Winnifried Wollner (Universität Hamburg)

MS05: Advances in Application-Oriented Computation and Optimization

Organizers: Abdul Khaliq (Middle Tennessee State University) and Qin Sheng (Baylor University), Bruce Wade (University of Louisiana at Lafayette), Xiang-Sheng Wang (University of Louisiana at Lafayette)

Time: Friday (11/3) 03:00 pm - 05:00 pm, Saturday (11/4) 03:45 pm - 04:45 pm, Sunday (11/5) 09:45 am - 10:45 am, Sunday (11/5) 11:00 am - 01:00 pm
Venue: Griffin 129

B1.1 Time: Friday (11/3) 03:00 pm - 03:30 pm

Title: Expressibility of the Global Difference of Exponential Splitting Approximations

Presenter: Tiffany Frugé Jones

Affiliation: Sam Houston State University, Huntsville, TX

Abstract: Various exponential splitting formulas have been influential in the approximation of the solutions of linear and nonlinear partial differential equations. While conventional concerns, including stability, efficiency, and truncated error analysis, are well studied, natural questions arise in the use of such exponential splitting methods. What is the effect of changing the summation ordering prior to employing a splitting approximation? What is the role of the commutativity of the matrices used? These concerns may be especially important when further applications to deep machine learning are intended. To that end, we will analyze the expressibility of the *global differences* incurred by such a change. Finally, remarks related to the analysis and simulation results in realistic applications will be presented.

Authors: Tiffany Frugé Jones (Sam Houston State University) and Qin Sheng (Baylor University)

B1.2 Time: Friday (11/3) 03:30 pm - 04:00 pm

Title: A study of a time-space nonuniform finite difference approximation of the Kawarada equation solutions

Presenter: Eduardo Servin Torres

Affiliation: Baylor University

Abstract: Modeling the combustion process found in a rocket's engine has been done with the help of Nonlinear Kawarada equations. For simplicity when investigating the numerical stability of approximations, the nonlinear term of the equation is linearized. This leaves certain ambiguity and uncertainty in the analysis. This talk develops a method to prove stability without the need to freeze the nonlinear source term. The method utilizes nonuniform grids generated through a quenching seeking moving mesh method in space and arc-length adaptation in time. Pointwise convergence will be studied with the aid of the Milne device. Simulation experiments will be carried out to accompany the mathematical analysis to strengthen our investigations.

Authors: Eduardo Servin Torres (Baylor University) and Qin Sheng (Baylor University)

B1.3 Time: Friday (11/3) 04:00 pm - 04:30 pm

Title: Some theoretical results on finite convergence property of Anderson acceleration on linear systems

Presenter: Yunhui He

Affiliation: University of Houston

Abstract: In this talk, we consider Anderson acceleration with window size m (AA(m)) applied to fixed-point iteration for linear systems. We explore some conditions on the $m+1$ initial guesses of AA(m), aiming for the residuals $r_{m+1} = 0$. We propose the sufficient and necessary conditions on the $m+1$ initial guesses for $r_{m+1} = 0$. These findings can help us better understand the performance

between original fixed-point iteration and Anderson acceleration. Meanwhile, it may give us some guidance on the choice of good initial guesses.

Authors: Yunhui He

B1.4 Time: Friday (11/3) 04:30 pm - 05:00 pm

Title: Double Inertial Iterative Schemes and Dynamical System

Presenter: Olaniyi Samuel Iyiola

Affiliation: Morgan State University

Abstract: Construction of the e cient iterative schemes for solving variational inequality problems (VIP) and the development of robust numerical schemes for solving systems of dif- ferential e- quations are active research areas for several years. In this talk, an overview of the relationship that exists between dynamical systems and several fixed point iterative methods will be presented. Furthermore, our recent results on the subgradient-extragradient method with double inertial ex- trapolation terms and self-adaptive step sizes for solving VIP will be discussed. This version is more relaxed with easy to implement conditions on the inertial-factor and relaxation parameter. Some examples are provided for implementation and comparison purposes.

Authors: Olaniyi Samuel Iyiola (Morgan State University)

B4.1 Time: Saturday (11/4) 03:45 pm - 04:15 pm

Title: Sparse Data Regulation on GRUs Neural Network for Solving Time-Dependent PDEs

Presenter: Jie Long

Affiliation: Middle Tennessee State University

Abstract: Deep learning algorithms have been widely applied for solving partial differential equations (PDEs). The feedforward neural networks (FNNs) demonstrate the competitive abilities to solve some PDEs. Compared to the FNNs, Recurrent Neural Networks (RNNs) are more suited to solve problems with sequential input data. Furthermore, Gated Recurrent Units (GRUs) are used to address some issues, like the vanishing gradient problem, of RNNs. However, the GRUs require plenty of data to achieve exceptional accuracy. In this talk, we will present utilizing the GRU neural network to solve the time dependent PDEs with sparse data. The neural network approximates the time iteration schemes, and then we propose the Adams Moulton implicit method to force them to converge to the solutions by training the network. The Sparse data are added as the regulator to achieve competitive accuracy. This algorithm has been applied to several numerical experiments, including Burgers, Allen-Cahn, and Schrodinger equations, to validate the feasibility.

Authors: Jie Long (Middle Tennessee State University) and Abdul Khaliq (Middle Tennessee State University)

B4.2 Time: Saturday (11/4) 04:15 pm - 04:45 pm

Title: Accelerate Sampling Using Birth-Death Dynamics

Presenter: Lihan Wang

Affiliation: Carnegie Mellon University

Abstract: I will discuss the birth-death dynamics for sampling multimodal probability distributions, which is the spherical Hellinger gradient flow of relative entropy. The advantage of the birth-death dynamics is that, unlike any local dynamics such as Langevin dynamics, it allows global movement of mass directly from one mode to another, without the difficulty of going through low probability regions. We prove that the birth death dynamics converges to the unique invariant measure with a uniform rate under some mild conditions, showing its potential of overcoming metastability. We will also show that on torus, the kernelized dynamics, which is used for numerical simulation, Gamma-converges to the idealized dynamics as the kernel bandwidth shrinks to zero.

Authors: Lihan Wang (Carnegie Mellon University) and Yulong Lu (Minnesota) and Dejan Slepcev (CMU)

B4.3 Time: Sunday (11/5) 09:45 am - 10:15 am

Title: Numerical methods for equations governing partial melting materials

Presenter: Chenyu Tian

Affiliation: University of Texas at Austin

Abstract: Modeling partial melting materials, such as the earth mantle or glaciers, poses significant challenges. We employ a discretization approach for the Darcy-Stokes flow problem, utilizing a modified Bernardi-Raugel like element defined using the lowest order direct serendipity space for Stokes flow, and a variant of the lowest order reduced H(div) AC space for the Darcy part. The scheme is locally mass conserved and modified for no melting situation. We also applied a recently developed multi-level WENO scheme to address the degenerate convection-diffusion problem that arises when melting presents in the material.

Authors: Chenyu Tian (University of Texas at Austin) and Todd Arbogast (University of Texas at Austin)

B4.4 Time: Sunday (11/5) 10:15 am - 10:45 am

Title: Immersed Virtual Element Methods for H(curl) Interface Problems in Three Dimensions

Presenter: Shuhao Cao

Affiliation: UMKC

Abstract: Finite element methods for electromagnetic problems modeled by Maxwell-type equations are highly sensitive to the conformity of approximation spaces, and non-conforming methods may cause loss of convergence. This fact leads to an essential obstacle for almost all the interface-unfitted mesh methods in the literature regarding the application to electromagnetic interface problems, as they are based on non-conforming spaces. In this work, a novel immersed virtual element method for solving a three-dimensional H(curl) interface problem is developed, and the motivation is to combine the conformity of virtual element spaces and robust approximation capabilities of immersed finite element spaces. The proposed method is able to achieve optimal convergence. In addition, the de Rham complex will be established based on which the Hiptmair-Xu (HX) preconditioner can be used to develop a fast solver for the H(curl) interface problem.

Authors: Shuhao Cao (UMKC) and Long Chen (UCI) and Ruchi Guo (CUHK)

B5.1 Time: Sunday (11/5) 11:00 am - 11:30 am

Title: Modeling Supraventricular Tachycardia Using Dynamic Computer-Generated Left Atrium

Presenter: Bryant Wyatt

Affiliation: Tarleton State University

Abstract: Supraventricular Tachycardia (SVT) occurs when the heart's atria beat rapidly or irregularly compared to the ventricles. Although not immediately fatal, this disharmony contributes to strokes, heart attacks, and heart failure. Catheter ablation is the primary treatment, wherein an electrophysiologist creates a 3D heart map, guiding a catheter to burn aberrant tissue with RF energy. Despite advances, gaps persist in understanding SVT triggers and optimal ablation sites, especially in cases like atrial fibrillation (AF). To address these gaps, our team has created a model of the left atrium that beats in real-time and is adjustable down to the level of individual muscles. Users can implement ablation strategies on our digital twin to quickly gain insights outside of the operating room. Patient data can be imported directly from a CT scan and electro-cardial mapping. This approach accelerates SVT comprehension without endangering lives. Our work holds life-saving potential that could revolutionize cardiac care.

Authors: Bryant Wyatt (Tarleton State University) and Gavin McIntosh (Tarleton State University)

B5.2 Time: Sunday (11/5) 11:30 am - 12:00 pm

Title: Global Regularity Issue of the Hall-Magnetohydrodynamics System

Presenter: Mohammad Mahabubur Rahman

Affiliation: Sam Houston State University

Abstract: Whether or not the solution to the $2\frac{1}{2}$-dimensional Hall-magnetohydrodynamics system starting from smooth initial data preserves its regularity for all time remains a challenging open problem due to its intricate term called the Hall-term. This talk discusses the proof of the challenging problem, however, where the sum of the derivatives in diffusion that our global regularity result requires $11 + \varepsilon$ for any ε ¿ 0 while the analogous sum for the classical $2\frac{1}{2}$-dimensional Hall-magnetohydrodynamics system is 12 considering $-\Delta u$ and $-\Delta b$.

Authors: Mohammad Mahabubur Rahman & Kazuo Yamazaki

B5.3 Time: Sunday (11/5) 12:00 pm - 12:30 pm

Title: Seismic sparse-layer reflectivity inversion using basis pursuit decomposition

Presenter: Rui Zhang

Affiliation: University of Louisiana at Lafayette

Abstract: Basis pursuit inversion of seismic reflection data for reflection coefficients is introduced as an alternative method of incorporating a priori information in a seismic inversion process. The inversion is accomplished by building a dictionary of functions, representing seismic reflection responses, and constituting the seismic trace as a superposition of these responses. Basis pursuit decomposition finds a sparse number of reflection responses that sum to form the seismic trace. When the dictionary of functions is chosen to be a wedge model of reflection coefficient pairs convolved with the seismic wavelet, the resulting reflectivity inversion is a sparse-layer inversion, rather than a sparse-spike inversion. Synthetic tests show that sparse-layer inversion using basis pursuit can better resolve thin beds than a comparable sparse-spike inversion can. Application to field data indicates that sparse-layer inversion results in potentially improved detectability and resolution of some thin layers and reveals apparent stratigraphic features that are not readily seen on conventional seismic sections.

Authors: Rui Zhang (School of Geosciences, University of Louisiana at Lafayette) and John Castagna (University of Houston)

B5.4 Time: Sunday (11/5) 12:30 pm - 01:00 pm

Break/Discussion

MS06: Applications of combinatorial and computational algebraic geometry

Organizers: Henry K. Schenck (Auburn)
Time: Saturday (11/4) 01:30 pm - 03:30 pm, Saturday (11/4) 03:45 pm - 04:45 pm, Sunday (11/5) 09:45 am - 10:45 am
Venue: Griffin 201

B3.1 Time: Saturday (11/4) 01:30 pm - 02:00 pm

Break/Discussion

B3.2 Time: Saturday (11/4) 02:00 pm - 02:30 pm

Title: Critical Points of Discrete Periodic Operators

Presenter: Matthew Faust

Affiliation: Texas A&M University

Abstract: The spectral gap conjecture is a well known and widely believed conjecture in mathematical physics concerning the structure of the Bloch variety (dispersion relation) of periodic operators. The Bloch variety of a discrete operator is algebraic, inviting methods from algebraic geometry to their study. Motivated by this conjecture, this talk will give a bound on the number of critical points of the dispersion relation for discrete periodic operators, and provide a general criterion for when this bound is achieved. We also present a class of periodic graphs for when this criteria is satisfied for Schrödinger operators. This is joint work with Frank Sottile.

Authors: Matthew Faust (Texas A&M University), Frank Sottile (Texas A&M University)

B3.3 Time: Saturday (11/4) 02:30 pm - 03:00 pm

Title: Invariants of the Dispersion Relation for Discrete Periodic Operators

Presenter: Jonah Robinson

Affiliation: Texas A&M

Abstract: We utilize tools of computational algebraic geometry to study the dispersion relation for discrete Schrödinger operators with generic parameters on various periodic graphs, with the goal of better understanding the geometry of critical points of the Bloch variety. In pursuit of this goal we study various invariants of the dispersion relation; such as Newton polytope, singular and degenerate loci, and the singular loci of its facial systems. Our investigations were carried out using Macaulay2 and the Texas A&M Mathematics department's computational cluster, Whistler, enabling us to harvest data for all small graphs with various fixed supports. In this talk, we present various phenomena observed in this study as well as several conjectures arising from these observations.

Authors: Matthew Faust, Jonah Robinson, Frank Sottile

B3.4 Time: Saturday (11/4) 03:00 pm - 03:30 pm

Title: $\mathbb{A}^1$-Brouwer Degrees in Macaulay2

Presenter: Jordy Lopez Garcia

Affiliation: Texas A&M University

Abstract: $\mathbb{A}^1$-Enumerative Geometry applies tools from homotopy theory to study enumerative geometry over arbitrary fields. We implement algorithms in the software system Macaulay2 to

compute $\mathbb{A}^1$-Brouwer degrees, which are invariants valued in classes of symmetric bilinear forms over a field. This project is based on the work by Brazelton, McKean and Pauli.

Authors: Nikita Borisov (University of Pennsylvania), Thomas Brazelton (Harvard University), Frenly Espino (University of Pennsylvania), Jordy Lopez Garcia (Texas A&M University), Zhaobo Han (University of Pennsylvania), Thomas Hagedorn (The College of New Jersey), Joel Louwsma (Niagara University), Andrew Tawfeek (University of Washington), Gabriel Ong (Bowdoin College)

B4.1 Time: Saturday (11/4) 03:45 pm - 04:15 pm

Title: Lex-segment initial ideals and the dimension of planar splines

Presenter: Michael DiPasquale

Affiliation: New Mexico State University

Abstract: The real vector space of piecewise polynomials (splines) of degree at most d and continuously differentiable to order r on a (finite) planar triangulation is a fundamental tool in approximation theory, numerical analysis, and in applications such as computer aided geometric design. Nevertheless, basic questions about this vector space remain unanswered. In particular, the dimension of the space of splines is not known for arbitrary triangulations when the degree (d) of the polynomials is within the range $r + 1 \leq d \leq 3r$. One of the few cases that has been known since the 1980s, due to Schumaker, is the dimension of splines on a collection of triangles that share a common vertex (called a vertex star). We present a dimension formula for splines in the next most complicated case – that is the case when the triangulation has a single totally interior edge. Our methods make use of the fact that an ideal generated by powers of linear forms in two variables tends to have an initial ideal which is lex-segment.

Authors: Michael DiPasquale (New Mexico State University) and Beihui Yuan (Beijing Institute of Mathematical Sciences and Applications)

B4.2 Time: Saturday (11/4) 04:15 pm - 04:45 pm

Title: Kuramoto Oscillators: Algebra and Topology

Presenter: Hal Schenck

Affiliation: Auburn University

Abstract: We investigate algebraic and topological signatures of networks of coupled oscillators. Translating dynamics into a system of algebraic equations enables us to identify classes of network topologies that exhibit unexpected behaviors. Many previous studies focus on synchronization of networks having high connectivity, or of a specific type (e.g. circulant networks). We introduce the Kuramoto ideal; an algebraic analysis of this ideal allows us to identify features beyond synchronization, such as positive dimensional components in the set of potential solutions (e.g. curves instead of points). We prove sufficient conditions on the network structure for such solutions to exist. The points lying on a positive dimensional component of the solution set can never correspond to a linearly stable state. We apply this framework to give a complete analysis of linear stability for all networks on at most eight vertices. Furthermore, we describe a construction of networks on an arbitrary number of vertices having linearly stable states that are not twisted stable states.

Authors: Heather Harrington (Oxford University and Max Planck), Hal Schenck (Auburn) and Mike Stillman (Cornell University)

B4.3 Time: Sunday (11/5) 09:45 am - 10:15 am

Break/Discussion

B4.4 Time: Sunday (11/5) 10:15 am - 10:45 am

Break/Discussion

MS07: Higher Order and Minimum Residual Finite Element Methods

Organizers: Stefan Henneking (UT Austin) and Judith Muñoz (Basque Center for Applied Mathematics) and Leszek Demkowicz (UT Austin)
Time: Friday (11/3) 03:00 pm - 05:00 pm, Saturday (11/4) 09:45 am - 11:45 am
Venue: Griffin 130

B1.1 Time: Friday (11/3) 03:00 pm - 03:30 pm

Title: Mixed Hybrid and Hybridizable Discontinuous Galerkin Method for Flow and Transport

Presenter: Beatrice Riviere

Affiliation: Rice University

Abstract: This talk presents a hybrid mixed-hybridizable discontinuous Galerkin method for coupled flow and transport problems. The resulting velocity is H(div)-conforming. Optimal error estimates are derived via the means of a special projection. Simulations show the benefit of using high order approximations.

Authors: Beatrice Riviere (Rice University) and Keegan Kirk (Rice University)

B1.2 Time: Friday (11/3) 03:30 pm - 04:00 pm

Title: Exploring Financial Derivatives through the Lens of the DPG Approach: A Study on Option Pricing and Sensitivity Analysis

Presenter: Davood Damircheli

Affiliation: Louisiana State University

Abstract: The Discontinuous Petrov-Galerkin (DPG) approach, first presented by Demkowicz and Gopalakrishnan [1], has solidified its place in computational mechanics. In our research, we've broadened the scope of the DPG technique, applying it to financial option pricing and sensitivity analysis using the Black-Scholes model framework. We introduce a tailored adaptation of the DPG approach, employing both its primal and ultraweak versions, to study a variety of options, including Vanilla, American, Asian, and Barrier. This sophisticated mathematical approach offers a thorough means of exploring intricate financial derivatives. We've conducted extensive numerical tests to confirm the method's convergence, stability, and efficiency for different option types. These tests confirm our method's efficacy in addressing diverse option pricing scenarios.

Authors: Davood Damircheli (Louisiana State University)

B1.3 Time: Friday (11/3) 04:00 pm - 04:30 pm

Title: Towards high order methods for incompressible Navier-Stokes equations with variable density

Presenter: Loic Cappanera

Affiliation: University of Houston

Abstract: The development of numerical methods for incompressible multiphase flows is important for many applications in engineering and geophysics (e.g., aluminum production, liquid metal battery, mantle convection). First, we will briefly present a projection-based method for incompressible flows with variable density which leads to solve a parabolic and an elliptic type problem. Then, we will introduce a method based on artificial compressibility techniques that has the main advantage of only requiring to solve a parabolic like problem to update the velocity-pressure couple. Both methods use a level set technique to track the fluids interface and use time-independent stiffness matrices. Theoretical results on the stability and convergence of both methods will be presented. Then the robustness and the accuracy of the methods are validated over various settings using finite element for the space discretization. Eventually, we will present some recent work showing that this artificial compressibility technique can be extended to a method of arbitrary high-order in time using a Taylor series technique originally developed by Guermond-Minev for incompressible flows with constant density.

Authors: Loic Cappanera (University of Houston) and Giselle Sosa Jones (Oakland University)

B1.4 Time: Friday (11/3) 04:30 pm - 05:00 pm

Title: A DPG method for the full-potential equation

Presenter: Jiaqi Li

Affiliation: University of Texas at Austin

Abstract: The full-potential equation is a model equation describing inviscid transonic flow. The governing PDE is of mixed type, which presents a challenge for numerical schemes. We propose to use a DPG method to solve linearized problems, in combination with Newton-Raphson iterations to tackle the nonlinearity. A post-processing approach is utilized to enforce the Kutta condition.

Authors: Jiaqi Li (University of Texas at Austin) and Leszek Demkowicz (University of Texas at Austin)

B2.1 Time: Saturday (11/4) 09:45 am - 10:15 am

Title: High order entropy stable schemes for the quasi-one-dimensional shallow water and compressible Euler equations

Presenter: Jesse Chan

Affiliation: Rice University

Abstract: High order entropy stable schemes improve robustness and ensure that physically relevant solutions satisfy a semi-discrete entropy inequality independently of discretization parameters. The construction of such schemes for nonlinear conservation laws relies on finite volume fluxes which satisfy an entropy conservation condition. For conservative systems, this condition is relatively simple; however, incorporating non-conservative terms can significantly complicate the analysis of such schemes. We present a modified condition which simplifies the construction and analysis of fluxes for systems involving non-conservative terms, and demonstrate its applicability to the quasi-1D shallow water equations and the quasi-1D compressible Euler equations.

Authors: Jesse Chan (Rice University)

B2.2 Time: Saturday (11/4) 10:15 am - 10:45 am

Title: Energy stable state redistribution cut-cell discontinuous Galerkin methods for wave propagation

Presenter: Christina G. Taylor

Affiliation: Rice University

Abstract: Here we present recent results on a provably energy stable cut cell wave propagation problem. Cut cell methods provide the ability to represent complex geometries while maintaining the simplicity of a Cartesian mesh wherever possible. However, cut cell meshes can result in extremely small and/or skewed cut elements that severely restrict the maximum stable time step of a simulation. We address this problem using state redistribution, which relaxes the CFL restrictions when small elements are present, layered on top of a provably energy stable high order discontinuous Galerkin formulation for the wave equation. The resulting method is provably L2 stable and we compare its results to an analytic benchmark for wave propagation.

Authors: Christina G. Taylor (Rice University) and Lucas Wilcox (Naval Postgraduate School) and Jesse Chan (Rice University)

B2.3 Time: Saturday (11/4) 10:45 am - 11:15 am

Title: A study of linear elasticity with DPG, and the nonlinear Cook's Membrane problem

Presenter: Jonathan Zhang

Affiliation: University of Texas at Austin

Abstract: We first investigate the linear elasticity problem in an L-shaped domain with a singular solution. We compare convergence results between two formulations: (1) standard Galerkin pure displacement and (2) standard Galerkin with DPG. We demonstrate how the DPG formulation enables adaptive mesh refinement, delivering convergence rates not limited by solution regularity. We present also some preliminary results on the nonlinear Cook's Membrane problem, including derivation of the linearized equations and numerical results.

Authors: Jonathan Zhang (University of Texas at Austin) and Leszek Demkowicz (University of Texas at Austin)

B2.4 Time: Saturday (11/4) 11:15 am - 11:45 am

Title: An Anisotropic *hp*-mesh Adaptation Framework for Ultraweak DPG Formulations

Presenter: Ankit Chakraborty

Affiliation: University of Texas at Austin

Abstract: Certain Petrov-Galerkin (PG) finite element schemes are inherently stable formulations of a variational problem on a given mesh. This stability is primarily obtained by computing a near-optimal test space corresponding to the prescribed approximation space. Additionally, these schemes are equipped with a robust inbuilt residual-based error estimator, thus making them an ideal candidate to complement adaptive mesh refinement. Nevertheless, the question remains: How can we use the inbuilt error estimator to drive mesh refinements to compute the optimal approximation space? In this work, we present a new automatic *hp*-adaptive anisotropic mesh-refinement strategy for ultraweak Discontinuous Petrov-Galerkin (DPG) formulations. The proposed strategy is a two-step process: (a) utilize the inbuilt error estimator to identify the elements that need refinement; and (b) once the identification is made, solve local projection problems on the identified elements to devise the optimal *hp*-refinement for the element. The result is an optimal *hp*-mesh that includes anisotropy in both space and polynomial order of approximation. We demonstrate the effectiveness and robustness of the proposed approach via 3D numerical experiments performed using the *hp*3D code.

Authors: Ankit Chakraborty (University of Texas at Austin) and Leszek Demkowicz (University of Texas at Austin)

MS08: Computational Methods for Kinetic and Hyperbolic Equations

Organizers: Juntao Huang (Texas Tech University)
Time: Saturday (11/4) 01:30 pm - 03:30 pm, Saturday (11/4) 03:45 pm - 04:45 pm, Sunday (11/5) 09:45 am - 10:45 am
Venue: Griffin 130

B3.1 Time: Saturday (11/4) 01:30 pm - 02:00 pm

Title: An S_N Discretization with Angular Adaptivity for Radiative Transfer Applications

Presenter: William A. Sands

Affiliation: University of Delaware

Abstract: In this talk, I will describe a new adaptive discrete ordinates S_N method for the steady-state radiative transfer equation. The approach we propose is iterative and begins with a coarse uniform angular discretization that is gradually updated to include new ordinates according to a simple adaptation rule. An advantage of the new method is that it is designed to be compatible with existing transport sweep algorithms that utilize discontinuous Galerkin spatial discretizations to compute the radiant fluxes. We apply the algorithms to several test problems and compare their accuracy against analytical solutions whenever possible. In the applications of interest to us, scattering plays a negligible role, so we focus on free-streaming limits. However, this assumption does not limit the applicability of the method, and we suggest some changes that can be made to accommodate scattering. We find the adaptive scheme to be highly effective in suppressing the ray-effects due to under-resolved angular discretizations.

Authors: William A. Sands (University of Delaware) and George Biros (University of Texas at Austin)

B3.2 Time: Saturday (11/4) 02:00 pm - 02:30 pm

Title: A Hybrid Monte Carlo, Discontinuous Galerkin method for linear kinetic transport equations

Presenter: Johannes Krotz

Affiliation: University of Tennessee Knoxville

Abstract: We present a hybrid method for time-dependent particle transport problems that combines Monte Carlo (MC) estimation with deterministic solutions based on discrete ordinates. For spatial discretizations, the MC algorithm computes a piecewise constant solution and the discrete ordinates uses bilinear discontinuous finite elements. From the hybridization of the problem, the resulting problem solved by Monte Carlo is scattering free, resulting in a simple, efficient solution procedure. Between time steps, we use a projection approach to "relabel" collided particles as uncollided particles. From a series of standard 2-D Cartesian test problems we observe that our hybrid method has improved accuracy and reduction in computational complexity of approximately an order of magnitude relative to standard discrete ordinates solutions.

Authors: Johannes Krotz (University of Tennessee Knoxville) and Cory D. Hauck (Oak Ridge National Laboratory) and Ryan G. McClarren (University of Notre Dame)

B3.3 Time: Saturday (11/4) 02:30 pm - 03:00 pm

Title: Fast solver for radiative transfer based on integral formulation

Presenter: Yimin Zhong

Affiliation: Auburn University

Abstract: Constructing efficient numerical solution methods for the equation of radiative transfer (ERT) remains a challenging task in scientific computing despite the tremendous development on the subject in recent years. In this talk, I will present a simple fast computational algorithm for solving the ERT in isotropic media in steady-state and time-dependent settings. The algorithm we developed has two steps. In the first step, we solve a volume integral equation for the angularly-averaged ERT solution using iterative schemes such as the GMRES method. The computation in this step is accelerated with a fast multipole method (FMM). In the second step, we solve a scattering-free transport equation to recover the angular dependence of the ERT solution. The algorithm does not require the underlying medium to be homogeneous. We present numerical simulations under various scenarios to demonstrate the performance of the proposed numerical algorithm for both homogeneous and heterogeneous media. Then I will extend the formulation to anisotropic scattering media and analyze the possibility to apply the fast algorithm.

Authors: Yimin Zhong (Auburn University) and Hongkai Zhao (Duke University) and Kui Ren (Columbia University)

B3.4 Time: Saturday (11/4) 03:00 pm - 03:30 pm

Title: Hyperbolic machine learning moment closure models for the radiative transfer equation

Presenter: Juntao Huang

Affiliation: Texas Tech University

Abstract: In this talk, we take a data-driven approach and apply machine learning to the moment closure problem for the radiative transfer equation. Instead of learning the unclosed high order moment, we propose to directly learn the gradient of the high order moment using neural networks, called the gradient-based moment closure. Moreover, we introduce two approaches to enforce the hyperbolicity of our gradient-based machine learning moment closures. A variety of benchmark tests, including the variable scattering problem, the Gaussian source problem and the two material problem, show both good accuracy and generalizability of our machine learning closure model.

Authors: Juntao Huang (Texas Tech University) and Yingda Cheng (Virginia Tech) and Andrew J. Christlieb (Michigan State University) and Luke F. Roberts (Los Alamos National Laboratory)

B4.1 Time: Saturday (11/4) 03:45 pm - 04:15 pm

Title: Superconvergence and accuracy enhancement of discontinuous Galerkin solutions for Vlasov-Maxwell equations

Presenter: Andrés Felipe Galindo-Olarte

Affiliation: University of Texas at Austin - ODEN institute

Abstract: In this talk we will explore the discontinuous Galerkin (DG) methods for solving the Vlasov-Maxwell (VM) system, a fundamental model for collisionless magnetized plasma. The DG method provides an accurate numerical description with conservation and stability properties. This work studies the applicability of a post-processing technique to the DG solution in order to enhance its accuracy and resolution for the VM system. In particular, superconvergence in the negative-order norm for the probability distribution function and the electromagnetic fields is established for the DG solution. Numerical tests including Landau damping, two-stream instability, and streaming Weibel instabilities are considered showing the performance of the post-processor.

Authors: Andrés Felipe Galindo-Olarte (University of Texas at Austin), Juntao Huang (Texas Tech University), Jennifer K Ryan (KTH Royal Institute of Technology) and Yingda Cheng (Virginia Tech)

B4.2 Time: Saturday (11/4) 04:15 pm - 04:45 pm

Title: Stability and convergence analysis of the Fourier-Galerkin spectral method for the Boltzmann equation

Presenter: Kunlun Qi

Affiliation: University of Minnesota - Twin Cities

Abstract: Numerical approximation of the Boltzmann equation is a challenging problem due to its high-dimensional, nonlocal, and nonlinear collision integral. Over the past decade, the Fourier-Galerkin spectral method has become a popular deterministic method for solving the Boltzmann equation, manifested by its high accuracy and potential of being further accelerated by the fast Fourier transform. Albeit its practical success, the stability of the method is only recently proved by utilizing the "spreading" property of the collision operator. In this talk, we introduce a new proof based on a careful L^2 estimate of the negative part of the solution. We also discuss the applicability of the result to various initial data, including both continuous and discontinuous functions.

Authors: Kunlun Qi (University of Minnesota - Twin Cities) and Jingwei Hu (University of Washington) and Tong Yang (Hong Kong Polytechnic University)

B4.3 Time: Sunday (11/5) 09:45 am - 10:15 am

Title: An Efficient Nonsmooth Convex Optimization-based High-order Accurate Bound-preserving Limiter for time-dependent Problems

Presenter: Chen Liu

Affiliation: Purdue University

Abstract: For time-dependent partial differential equations, the numerical schemes can be rendered bound-preserving without losing conservation and accuracy, by a postprocessing procedure of solving a constrained minimization at each time step. Such a constrained optimization can be formulated as a nonsmooth convex minimization problem, which can be efficiently solved by the Douglas-Rachford method if using the optimal algorithm parameters. By analyzing the asymptotic linear convergence rate of the generalized Douglas-Rachford splitting method, optimal algorithm parameters can be approximately expressed as a simple function of the numerical solutions. Numerical tests on phase-field problems and conservation law problems indicate that our limiter is high-order accurate, very efficient, and well-suited for large-scale simulations. Examples include the Cahn-Hilliard-Navier-Stokes system and the compressible Navier-Stokes system.

Authors: Chen Liu (Purdue University) and Xiangxiong Zhang (Purdue University)

B4.4 Time: Sunday (11/5) 10:15 am - 10:45 am

Title: Oscillation-Eliminating Discontinuous Galerkin Methods for Hyperbolic Conservation Laws

Presenter: Zheng Sun

Affiliation: The University of Alabama

Abstract: In this presentation, we introduce a post-processing approach aimed at controlling spurious oscillations near shock waves in the simulation of hyperbolic conservation laws using the Discontinuous Galerkin (DG) method. This method is founded on the damping technique developed in the oscillation-free DG method [J. Lu, Y. Liu, and C.-W. Shu, SIAM J. Numer. Anal., 59

(2021), pp. 1299–1324] and is referred to as the Oscillation-Eliminating DG (OEDG) method. To enhance robustness, a new set of scaling-invariant damping coefficients is introduced. The OEDG method is straightforward to implement, capable of handling strong shocks without relying on exponential Runge–Kutta methods for the treatment of the stiff damping terms, and can produce satisfactory results without the need for characteristic decomposition. We also provide rigorous optimal error estimates for linear advection equations for the fully discrete and nonlinear OEDG scheme. Additionally, we include numerical examples to illustrate the method's performance.

Authors: Manting Peng (Southern University of Science and Technology), Zheng Sun (The University of Alabama) and Kailiang Wu (Southern University of Science and Technology)

MS09: Computational nonlinear algebra

Organizers: Frank Sottile (Texas A& M University)
Time: Saturday (11/4) 01:30 pm - 03:30 pm, Sunday (11/5) 11:00 am - 01:00 pm
Venue: Griffin 204

B3.1 Time: Saturday (11/4) 01:30 pm - 02:00 pm

Title: Tensor products of reproducing kernel Banach spaces

Presenter: Zehua Lai

Affiliation: University of Texas at Austin

Abstract: Classical kernel methods are powerful learning methods that greatly enhance the interpretability of deep learning theory. The general concept underlying the kernel method is the reproducing kernel Banach space (RKBS). We discuss the construction of tensor products of reproducing kernel Banach spaces and its application to multiplicatively separable regression.

Authors: Zehua Lai (University of Texas at Austin), Feiyu Han (University of Chicago), Lek-Heng Lim (University of Chicago)

B3.2 Time: Saturday (11/4) 02:00 pm - 02:30 pm

Title: SchubertIdeals.m2: A Software Package for the Schubert Calculus of Flag Varieties

Presenter: C.J. Bott

Affiliation: Texas A&M University

Abstract: Flag varieties form a fascinating class of algebraic manifolds, with important examples being projective spaces, Grassmannians, Lagrangian Grassmannians, and the full flag manifolds of classical Lie types. We present a Macaulay2 package that does Schubert calculus for flag varieties, i.e. computes intersections of their Schubert subvarieties. In the zero-dimensional case, we use cohomology calculations to count the number of points of intersection. In general, given a list of Schubert varieties in some flag variety, we compute the ideal of the intersection in terms of local coordinates.

Authors: C.J. Bott (Texas A&M University)

B3.3 Time: Saturday (11/4) 02:30 pm - 03:00 pm

Title: Computing isotopy type of positive zero sets faster for n-variate $(n + k)$-nomials

Presenter: Weixun Deng

Affiliation: Texas A&M University

Abstract: Consider an n-variate polynomial f with degree d, Newton polytope of dimension n, exactly $n+k$ monomial terms, and all coefficients in $\{\pm 1, \ldots, \pm H\}$. For the case $k = 2$, we prove that the positive zero set of f is isotopic to the real zero set of an explicit n-variate quadric q, and give a fast algorithm to explicitly compute q: The bit complexity is $(\log(dH))^{O(n)}$. The best previous bit-complexity bounds were of the form $(d\log(H))^{\Omega(n)}$. The underlying tools are important for the case $k = 3$ and beyond. In particular, we'll see how further speed-ups are possible for a large set of inputs. This is joint work with Frederic Bihan, Erika Cory, Kaitlyn Phillipson, Robert J. Rennie, and J. Maurice Rojas.

Authors: Frederic Bihan, Erika Cory, Weixun Deng, Kaitlyn Phillipson, Robert J. Rennie, and J. Maurice Rojas

B3.4 Time: Saturday (11/4) 03:00 pm - 03:30 pm

Title: Efficient Bounds and Estimates for Canonical Angles in Randomized Subspace Approximations

Presenter: Yijun Dong

Affiliation: University of Texas at Austin

Abstract: Randomized subspace approximation with matrix sketching is an effective approach for constructing approximate partial singular value decompositions (SVDs) of large matrices. The performance of such techniques has been extensively analyzed, and very precise estimates on the distribution of the residual errors have been derived. However, our understanding of the accuracy of the computed singular vectors (measured in terms of the canonical angles between the spaces s-panned by the exact and the computed singular vectors, respectively) remains relatively limited. In this work, we present bounds and estimates for canonical angles of randomized subspace approximation that can be computed efficiently either a priori or a posterior. Under moderate oversampling in the randomized SVD, our prior probabilistic bounds are asymptotically tight and can be computed efficiently, while bringing a clear insight into the balance between oversampling and power iterations given a fixed budget on the number of matrix-vector multiplications. The numerical experiments demonstrate the empirical effectiveness of these canonical angle bounds and estimates on different matrices under various algorithmic choices for the randomized SVD

Authors: Yijun Dong (UT Austin)

B5.1 Time: Sunday (11/5) 11:00 am - 11:30 am

Title: Near-optimal bounds for the number of p-adic roots of circuit systems

Presenter: Joshua Goldstein

Affiliation: Texas A&M

Abstract: Consider polynomials $f_1, \ldots, f_n \in \mathbb{Z}[x_1, \ldots, x_n]$ each having the same $n+2$ exponent vectors and the same Newton polytope of dimension n. We call $F = (f_1, \ldots, f_n)$ a circuit system. A tight upper bound of $n+1$ is known for the number of non-degenerate roots of F in the positive orthant. We prove a p-adic analogue of this fact when p¿n+2 and p is prime: The number of non-degenerate p-adic rational roots of F, with all coordinates having most significant digit 1, is at most n+2. The best previous upper bound was exponential in n and the best lower bound is $n+1$. We discuss the main underlying techniques, which involves tropical geometry and a data structure for the p-adic roots of univariate polynomials. This is joint work with J. Maurice Rojas.

Authors: Joshua Goldstein (Texas A&M), J. Maurice Rojas (Texas A&M)

B5.2 Time: Sunday (11/5) 11:30 am - 12:00 pm

Title: Applications of Real Algebraic Geometry to Neural Networks and Optimization

Presenter: Yifan Zhang

Affiliation: University of Texas at Austin

Abstract: In this talk I will describe some new results in real algebraic geometry and their applications to deep neural networks, optimization over varieties, etc.

Authors: Yifan Zhang and Joe Kileel (University of Texas at Austin)

B5.3 Time: Sunday (11/5) 12:00 pm - 12:30 pm

Title: Discriminants in Weighted Low-Rank Approximation

Presenter: Elzbieta Polak

Affiliation: University of Texas at Austin

Abstract: I will go over results regarding the discriminant associated with the Euclidean distance degree for real varieties. I will focus on the case of weighted low-rank matrix approximation and discuss open questions, conjectures and new approaches utilizing various methods. Based on joint work with Joe Kileel.

Authors: Elzbieta Polak (University of Texas at Austin) and Joe Kileel (University of Texas at Austin)

B5.4 Time: Sunday (11/5) 12:30 pm - 01:00 pm

Title: Rational approximations for computing critical points of analytic functions

Presenter: Georgy Scholten

Affiliation: Lip6 - LJLL, Sorbonne Université

Abstract: In this talk, we will present some preliminary results about computing critical points of analytic functions through the use of multivariate rational approximation functions. We will discuss the differences between rational and polynomial approximants, convergence rates and methods to compute rational approximants. Spurious poles often arise in rational approximants, and can be hard to detect numerically. We will look at heuristics strategies for erasing spurious poles and ways to certify that no solutions or critical points have been obstructed by such spurious poles.

Authors: Mohab Safey El Din (Lip6, Sorbonne Université), Emmanuel Trélat (LJLL, Sorbonne Université)

MS10: Data- and model-driven approaches for inverse problems

Organizers: Alexander Mamonov (Department of Mathematics, University of Houston) and Andreas Mang (Department of Mathematics, University of Houston) and Daniel Onofrei (Department of Mathematics, University of Houston)
Time: Saturday (11/4) 01:30 pm - 03:30 pm, Saturday (11/4) 03:45 pm - 04:45 pm, Sunday (11/5) 09:45 am - 10:45 am, Sunday (11/5) 11:00 am - 01:00 pm
Venue: Oliver 112

B3.1 Time: Saturday (11/4) 01:30 pm - 02:00 pm

Title: The Lippmann Schwinger Lanczos algorithm for inverse scattering problems

Presenter: Shari Moskow

Affiliation: Drexel University

Abstract: We combine data-driven reduced order models with the Lippmann-Schwinger integral equation to produce a direct nonlinear inversion method. The ROM is viewed as a Galerkin projection and is sparse due to Lanczos orthogonalization. Embedding into the continuous problem, a data-driven internal solution is produced. This internal solution is then used in the Lippmann-Schwinger equation, in a direct or iterative framework. The approach allows us to process more general transfer functions than the earlier versions of the ROM based inversion algorithms. We give examples of its use for spectral domain MIMO problems and in the time domain given mono static data, targeting synthetic aperture radar.

Authors: Vladimir Druskin (Worcester Polytechnic Institute) and Shari Moskow (Drexel University) and Mikhail Zaslavsky (Southern Methodist University)

B3.2 Time: Saturday (11/4) 02:00 pm - 02:30 pm

Title: A data-assisted two-stage method for the inverse random source problem

Presenter: Peijun Li

Affiliation: Purdue University

Abstract: We present a data-assisted two-stage method for solving an inverse random source problem of the Helmholtz equation. In the first stage, the regularized Kaczmarz method is employed to generate initial approximations of the mean and variance based on the mild solution of the stochastic Helmholtz equation. A dataset is then obtained by sampling the approximate and corresponding true profiles from a certain a-priori criterion. The second stage is formulated as an image-to-image translation problem, and several data-assisted approaches are utilized to handle the dataset and obtain enhanced reconstructions. Numerical experiments demonstrate that the data-assisted two-stage method provides satisfactory reconstruction for both homogeneous and inhomogeneous media with fewer realizations.

Authors: Peijun Li (Purdue University) and Ying Liang (Purdue University) and Yuliang Wang (Beijing Normal University, Zhuhai)

B3.3 Time: Saturday (11/4) 02:30 pm - 03:00 pm

Title: Spectral analysis of scattering resonances with application on high-contrast nanospheres

Presenter: Taoufik Meklachi

Affiliation: Penn State

Abstract: In this paper, we provide further spectral analysis of the general asymptotic scattering resonances formula of small 3D dielectrics of arbitrary shape with high contrast, already derived in other works to a first-order approximation. To investigate the components of a full expansion of such resonances, a breakdown is presented for the case of high-contrast nanospheres, in terms of its radius h in the interval [0, 1]. We also derive, for radially symmetric fields, an exact resonance formula for a spherical scatterer in terms of its radius, not necessarily small, and dielectric susceptibility coefficient, not necessarily high. This formula is further developed and simplified in the case of high contrast nanospheres. Such formulas are useful in imaging applications to identify objects' properties from frequency measurements.

Authors: Taoufik Meklachi (Penn State)

B3.4 Time: Saturday (11/4) 03:00 pm - 03:30 pm

Title: On the problem of personalized sound

Presenter: Daniel Onofrei

Affiliation: University of Houston

Abstract: In this talk we will present an overview of current approaches on the problem of personalized sound and then introduce and discuss our active control approach, which provides a unified mathematical framework for the understanding of the scope and limitations of personalized sound applications. We will provide an insightful comparison and present our analysis showing the robustness of our approach as well as its versatility when it comes to important extensions. Theoretical results and numerical investigations will be presented and discussed.

Authors: Daniel Onofrei (University of Houston)

B4.1 Time: Saturday (11/4) 03:45 pm - 04:15 pm

Title: Hyper-Differential Sensitivity Analysis with respect to Model Discrepancy: Optimal Experimental Design

Presenter: Bart van Bloemen Waanders

Affiliation: Sandia National Laboratories

Abstract: Hyper-Differential Sensitivity Analysis (HDSA) with respect to model-discrepancy is used to update approximate control solutions that emulate higher-fidelity physics by only using data from the high-fidelity physics. This approach avoids intrusive implementations but depends on small number of forward evaluations of the higher-fidelity models. In this presentation, we investigate strategic sampling algorithms using optimal experimental design concepts combined with HDSA and Bayesian Theory to reduce the error between the lower and higher-fidelity optimization solutions. We demonstrate our approach on various PDE exemplars and show improvements over random sampling.

Authors: Bart van Bloemen Waanders (Sandia National Laboratories) and Joseph Hart (Sandia National Laboratories)

B4.2 Time: Saturday (11/4) 04:15 pm - 04:45 pm

Title: Big Data Inverse Problems – Promoting Sparsity and Learning to Regularize

Presenter: Matthias Chung

Affiliation: Emory University

Abstract: Emerging fields such as data analytics, machine learning, and uncertainty quantification heavily rely on efficient computational methods for solving inverse problems. With growing model complexities and ever-increasing data volumes, state-of-the-art inference method exceeded their limits of applicability, and novel methods are urgently needed. In this talk, we present novel methods for the broad spectrum of inverse problems where the aim is to reconstruct quantities with a sparse representation on some vector space. The associated optimization problems with L1 regularization have received significant attention, due to their wide applicability in compressed sensing, dictionary learning, and imaging problems, to name a few. We present a new method based on variable projection and describe a new approach that uses deep neural networks (DNNs) to obtain regularization parameters for solving inverse problems. The aim of this talk is to engage students and faculty alike and initiate a discussion about future directions of computational mathematics in the world of big data and machine learning.

Authors: Matthias Chung (Emory University) and Rosemary Renaut (Arizona State University)

B4.3 Time: Sunday (11/5) 09:45 am - 10:15 am

Title: Randomized Preconditioners for SC-4DVAR

Presenter: Amit N Subrahmanya

Affiliation: Virginia Tech

Abstract: Computing the maximum a posteriori estimate in SC-4DVAR involves solving a minimization problem which we tackle using the Gauss-Newton Method. The computation of the descent direction is expensive since it involves a large linear solve of an ill-conditioned linear system. To address this cost, we efficiently construct scalable preconditioners using three different randomization techniques. The randomized techniques rely on a certain low-rank structure involving the Gauss-Newton Hessian. We also develop an adaptive approach to estimate the rank and to determine when to recompute the preconditioner. The proposed techniques are amenable to parallelization and drastically reduce the number of (Gauss-Newton) Hessian products. The proposed techniques also come with theoretical guarantees on the condition number.

Authors: Amit N Subrahmanya (Virginia Tech) and Vishwas Rao (Argonne National Laboratory) and Arvind K Saibaba (North Carolina State University)

B4.4 Time: Sunday (11/5) 10:15 am - 10:45 am

Title: Uncertainty Quantification in the Inverse Problem of Temporal Dynamic Systems for Medical Imaging: An Application to Alzheimer's Disease

Presenter: Zheyu Wen

Affiliation: The University of Texas at Austin

Abstract: Developing a robust temporal dynamic model to understand the propagation of pathological tau in Alzheimer's Disease poses significant challenges. These challenges arise from the heterogeneous distribution of tau in patients, limited time series datasets, and the need to extract abnormal tau patterns from signals. In this study, we introduce a two-species temporal dynamic model based on a coarse-grained graph representation of the brain. We employ an inversion technique to estimate the initial conditions of the system and operator parameters using observations at a single time point. To account for uncertainty, we treat each image sequence at a specific time of acquisition as a Gaussian distribution and quantify the inversion uncertainty. Our results demonstrate that the proposed inversion scheme achieves state-of-the-art fitting results while maintaining systematic stability throughout the entire inversion process.

Authors: Zheyu Wen (The University of Texas at Austin) and Ali Ghafouri (The University of Texas at Austin) and George Biros (The University of Texas at Austin)

B5.1 Time: Sunday (11/5) 11:00 am - 11:30 am

Title: Model-constrained uncertainty quantification for scientific deep learning of inverse solutions

Presenter: Tan Bui-Thanh

Affiliation: The University of Texas at Austin

Abstract: While Bayesian Neural Networks facilitate uncertainty quantification for neural network prediction, the uncertainty is questionable using Gaussian priors on the weights and biases. Clearly,

weights/biases are artificial quantities/parameter and thus Gaussian priors are the matter of convenience instead of rationale. In this talk we present of one of the first attempts to develop neural network solutions of inverse problems. Our approach not only incorporate the governing equations into account but also quantify the uncertainty in the neural network prediction in a principled fashion. Theoretical results will be presented and various numerical results will be provided to justify our approach.

Authors: Russell Philley (The University of Texas at Austin) and Hai V. Nguyen (The University of Texas at Austin) and Tan Bui-Thanh (The University of Texas at Austin)

B5.2 Time: Sunday (11/5) 11:30 am - 12:00 pm

Title: Completed-data-driven ROMs for SAR imaging

Presenter: Mikhail Zaslavsky

Affiliation: Southern Methodist University

Abstract: In this talk we consider the inverse scattering problem with monostatic time-domain data. Keeping in mind the synthetic aperture radars (SAR) applications, the data is assumed to be given by series of the single-input-single-output (SISO) channels corresponding to moving collocated sources and receivers. Interpolatory reduced-order models (ROMs) formulations we developed allow to learn the internal solutions using only data-driven Grammians of the time-domain snapshots. In particular, we construct internal solutions for each SISO channel separately and then couple them together via Lippmann-Schwinger integral equation. We also discuss how to improve the solution learning by enhancing the aperture via data completion that enables lifting of SISO data series to mulit-input-multi-output (MIMO) data. Numerical experiments illustrating the performance of our approach will be provided.

Authors: Mikhail Zaslavsky (Southern Methodist University) and Vladimir Druskin (Worcester Polytechnic Institute) and Shari Moskow (Drexel University)

B5.3 Time: Sunday (11/5) 12:00 pm - 12:30 pm

Title: Monotonically converging two-sided computable bounds for exponential matrix moments via Lanczos algorithm

Presenter: Vladimir Druskin

Affiliation: Worcester Polytechnic Institute

Abstract: We estimate exponential matrix moments $b^* \exp(-tA)b$, where b is a vector and A a s.p.d. matrix. They appear in many applications, e.g., numerical PDEs, graphs and machine learning. The Lanczos algorithm is the method of choice for computation of moments of large sparse A. Here we use the finite-difference representation of the Lanczos tridiagonal matrix to compute sharp upper and lower a-posteriori bounds on the solution. These bounds converge strictly monotonically and even remain valid in computer arithmetic, when the Lanczos algorithm loses orthogonality. The idea of the algorithm is originated in our earlier research on data-driven reduced order models for inverse scattering.

Authors: Vladimir Druskin (Worcester Polytechnic Institute) and Valeria Simoncini (University of Bologna, Italy) and Jorn Zimmerling (University of Uppsala, Sweden)

B5.4 Time: Sunday (11/5) 12:30 pm - 01:00 pm

Title: Bayesian nonparametric learning of stochastic differential equations

Presenter: Jinpu Zhou

Affiliation: Department of Mathematics, Louisiana State University

Abstract: In this talk we introduce a systematic approach for learning the entire drift function of a stochastic differential equation from high-frequency data. This differs from the parametric estimation problem, where the functional or parametric form of the drift function is assumed to be known barring a finite-dimensional parameter. Towards this end, we develop learning methods that merge optimization theory in RKHS with Bayesian techniques. Importantly, our Bayesian hierarchical framework incorporates low-cost sparse learning through the proper use of shrinkage priors while allowing proper quantification of uncertainty through posterior distributions. Several examples at the end illustrate the accuracy of our learning scheme.

Authors: Arnab Ganguly (Louisiana State University) and Riten Mitra (University of Louisville) and Jinpu Zhou (Louisiana State University)

MS11: Stability and Dynamics of Nonlinear Waves and Coherent Structures

Organizers: Alejandro Aceves (Southern Methodist University) and John Zweck (The University of Texas at Dallas)
Time: Friday (11/3) 03:00 pm - 05:00 pm, Saturday (11/4) 09:45 am - 11:45 am
Venue: Oliver 112

B1.1 Time: Friday (11/3) 03:00 pm - 03:30 pm

Title: Optimal Control of Branched Flow

Presenter: Jimmie Adriazola

Affiliation: Southern Methodist University

Abstract: Branched flow is a wave scattering phenomenon that produces a tree-like pattern and is understood to be ubiquitous across different systems such as height fluctuations of tsunamis, pulsar radiation propagating through the interstellar medium, the flow of electrons in semiconductors, and, more recently, light propagation in thin soap films. Besides being a novel scientific phenomenon, branched flow of light has been proposed as a means for probing biological membranes, thus making its mathematical description important for applications. In this talk, we will show how to numerically reproduce branched flow using Schrödinger optics. We will then formulate and show the numerical solution of an optimization problem that addresses the problem of maximally illuminating dark regions at the end of the propagation media. Questions about the well-posedness of the problem and other problems concerning the control of coherent branches in other physical scenarios will also be discussed.

Authors: Jimmie Adriazola (Southern Methodist University)

B1.2 Time: Friday (11/3) 03:30 pm - 04:00 pm

Title: A Chemotaxis Model With A Logistic Source On a Compact Graph

Presenter: Hewan Shemtaga

Affiliation: Auburn University

Abstract: In this work, we study a chemotaxis model with a logistic source defined on a compact metric graph (quantum graph). 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 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.

Authors: Hewan Shemtaga (Auburn University), Wenxian Shen (Auburn University), and Selim Sukhtaiev (Auburn University)

B1.3 Time: Friday (11/3) 04:00 pm - 04:30 pm

Title: A split-step method for a nonlinear nonlocal wave equation with applications to laser stability

Presenter: John Zweck

Affiliation: University of Texas at Dallas

Abstract: We investigate the linear stability of periodic pulses in a lumped model of a fiber laser with the aid of a monodromy operator obtained by linearizing the system about the pulse. We introduce a Fourier split-step method to compute solutions of the linearization of the nonlinear, nonlocal, stiff equation for optical propagation in the fiber amplifier. We use gradient-based optimization to discover periodic pulses and the spectrum of the monodromy operator to characterize pulse stability. We use theory and simulations to verify the accuracy of the numerical methods, and we show examples of periodic pulses, their spectra and eigenfunctions.

Authors: Vrushaly Shinglot (University of Texas at Dallas) and John Zweck (University of Texas at Dallas)

B1.4 Time: Friday (11/3) 04:30 pm - 05:00 pm

Title: Subharmonic Stability of Periodic Traveling Waves in Dissipative Systems

Presenter: Mat Johnson

Affiliation: The University of Kansas

Abstract: In this talk, we consider the nonlinear stability of spectrally stable T-periodic traveling wave solutions in dissipative systems. The perturbations are taken to be NT-periodic for some positive integer N. While classical stability results provide exponential decay to translates of the underlying wave, these results are not uniform in N and, in fact, degenerate in the limit $N \to \infty$. I will discuss a new methodology that provides stability estimates which are uniform in N, thus providing N-independent decay rates of perturbations along with allowable sizes of initial perturbations which are also N-independent.

Authors: Mat Johnson (The University of Kansas)

B2.1 Time: Saturday (11/4) 09:45 am - 10:15 am

Title: Stability of fronts in the diffusive Rosenzweig - MacArthur Model

Presenter: Anna Ghazaryan

Affiliation: Miami University

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. 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 current project is focused on the stability of the fronts. In particular, it is of interest whether the stability of the fronts is also governed by the scalar Fisher-KPP equation. The techniques of the analysis include a construction of unstable augmented bundles and their treatment as multiscale topological structures.

Authors: Anna Ghazaryan (Miami University), Yuri Latushkin (University of Missouri - Columbia), Stephane Lafortune (College of Charleston), and Vahagn Manukian (Miami University)

B2.2 Time: Saturday (11/4) 10:15 am - 10:45 am

Title: Patterns in Oscillatory Media with Nonlocal Coupling

Presenter: Gabriela Jaramillo

Affiliation: University of Houston

Abstract: Many physical and biological systems that exhibit time oscillations generate interesting patterns. For instance, it is well known that under appropriate conditions the Belousov-Zhabotinsky reaction generates spiral waves, target patterns, and other spatio-temporal structures. To understand the formation of these patterns one often views these systems as consisting of small oscillating element that interact with each together via diffusion or coupling. In this talk we explore what happens to these structures when these interactions are long-ranged and outline the mathematical tools needed to prove their existence.

Authors: Gabriela Jaramillo (University of Houston), Kevin Sony (University of Houston), Sameel Siddiqi (University of Central Florida)

B2.3 Time: Saturday (11/4) 10:45 am - 11:15 am

Title: Dynamics and localization in the discrete fractional nonlinear Schrödinger Equation

Presenter: Austin Marstaller

Affiliation: Southern Methodist University

Abstract: Recently, there has been increased interest in the study of the Fractional Nonlinear Schrödinger Equation (fNLSE). In the continuum case fractionality refers to the symbol $k^{2\alpha}, 0 < \alpha < 1$ instead of k^2 for the classical Laplace operator. In this work we consider the discrete version, for which coupling between units (waveguides, oscillators) is nonlocal, with algebraic decay in the coupling strength. We present results on modulational instability, existence of localized modes and their mobility as it relates to the form of the Peierls-Nabarro barrier. In all instances we compare our results with that of the well-known discrete Nonlinear Schrödinger equation.

Authors: Austin Marstaller (Southern Methodist University), Bian Choi (West Point Academy) and Alejandro Aceves(Southern Methodist University)

B2.4 Time: Saturday (11/4) 11:15 am - 11:45 am

Title: New perspective on modeling high power light propagation in nonlinear media

Presenter: Alexey Sukhinin

Affiliation: University of North Carolina at Greensboro

Abstract: High power light propagation in nonlinear media is a complex phenomenon that depends on many factors. Beam characteristics, media properties and light matter interaction contribute to the dynamics of travelling optical field. Understanding and modeling various propagation regimes are important for designing lasers that could find applications in areas such as communication, remote sensing, spectroscopy and atmospheric studies. In this talk, I will discuss and analyze several models that are based on Nonlinear Schrodinger Equation that describe various effects of high power electromagnetic wave in nonlinear media.

Authors: Alexey Sukhinin (University of North Carolina at Greensboro)

MS12: Discrete and Continuous Schrödinger Operators

Organizers: Matthew Faust (Texas A&M University) and Ilya Kachkovskiy (Michigan State University) and Alberto Takase (Rice University)
Time: Saturday (11/4) 01:30 pm - 03:30 pm, Saturday (11/4) 03:45 pm - 04:45 pm, Sunday (11/5) 09:45 am - 10:45 am, Sunday (11/5) 11:00 am - 01:00 pm
Venue: Oliver 101

B3.1 Time: Saturday (11/4) 01:30 pm - 02:00 pm

Title: Regularity of the Lyapunov exponent for multifrequency quasi-periodic cocycles

Presenter: Matthew Powell

Affiliation: Georgia Institute of Technology

Abstract: Many spectral properties of 1D Schrödinger operators have been linked to the Lyapunov exponent of the corresponding Schrödinger cocycle. While the situation for one-frequency quasi-periodic operators is well-understood, the multifrequency situation is not. The purpose of this talk is to discuss our recent and ongoing work on multi-frequency quasi-periodic cocycles, establishing continuity (both in cocycle and jointly in cocycle and frequency) of the Lyapunov exponent for non-identically singular cocycles, along with consequences for quasi-periodic Jacobi operators. Analogous results for one-frequency cocycles have been known for over a decade, but the multi-frequency results have been limited to either Diophantine frequencies (continuity in cocycle) or $SL(2, \mathbb{C})$ cocycles (joint continuity). We will discuss the main points of our argument, which extends earlier work of Bourgain.

Authors: Matthew Powell (Georgia Institute of Technology)

B3.2 Time: Saturday (11/4) 02:00 pm - 02:30 pm

Title: Logarithmic Capacities of Rational Frequency Approximants for Almost Mathieu Operator

Presenter: Burak Hatinoglu

Affiliation: Michigan State University

Abstract: In their "Analytic quasi-periodic Schrödinger operators and rational frequency approximants" paper, Svetlana Jitomirskaya and Chris Marx proved the following result: Consider a quasi-periodic Schrödinger operator $H_{\alpha,\theta}$ with analytic potential and irrational frequency α. Given any rational approximating α, let S_+ and S_- denote the union, respectively, the intersection of the spectra taken over θ. They showed that up to sets of zero Lebesgue measure, the absolutely continuous spectrum and the spectrum can be obtained asymptotically from S_- and S_+ of the periodic operators associated with the continued fraction expansion of α, respectively. In this talk, I will discuss these results with logarithmic capacity instead of Lebesgue measure for almost Mathieu operators. If time permits, I will talk some extensions to quasi-periodic Schrödinger operator with analytic potentials and irrational frequencies.

Authors: Burak Hatinoglu (Michigan State University) and Svetlana Jitomirskaya (University of California, Irvine)

B3.3 Time: Saturday (11/4) 02:30 pm - 03:00 pm

Title: Ballistic motion for Schördigner operators in a periodic strip model

Presenter: Tal Malinovitch

Affiliation: Rice University

Abstract: In this talk, we will consider the transport properties of Schrödinger operators on $\mathbb{R}^m$ and $\mathbb{Z}^m$ with potentials that are periodic in some directions and compactly supported in others. Such systems are known to produce "surface states" that are, in some sense, confined near the support of the potential. We show that, under very mild assumptions, a class of surface states exhibits a strong form of ballistic transport in the periodic directions and the absence of transport in the other directions. Roughly speaking, we say that a state exhibits ballistic motion if it spreads linearly in time ($x \sim t$- in some sense). Furthermore, on $\mathbb{Z}^2$, we show that a dense set of surface states exhibit this "directional ballistic transport." To get this result we generalized Simon's classic result on the absence of ballistic transport for pure point states *simon1990absence* and prove a folklore theorem about the transport of scattering states. In this talk, I will briefly review our main results and some of the tools used in this work. This is joint work with Adam Black, David Damanik, and Giorgio Young.

Authors: Adam Black (Yale University), David Damanik (Rice University), and Giorgio Young (University of Michigan)

B3.4 Time: Saturday (11/4) 03:00 pm - 03:30 pm

Title: Unique continuation, Wegner lemma, and localization for non-stationary random Schrödinger operators on $\mathbb{Z}^2$

Presenter: Omar Hurtado

Affiliation: University of California, Irvine

Abstract: We extend methods of Ding and Smart in their breakthrough paper from 2019 which showed Anderson localization for certain random Schrödinger operators on $\ell^2(\mathbb{Z}^2)$ via a quantitative unique continuation principle and Wegner estimate. We replace the requirement of identical distribution with the requirement of a uniform bound on the essential range of potential and a uniform positive lower bound on the variance of the variables giving the potential. Under those assumptions, we recover the unique continuation and Wegner lemma results, using Bernoulli decompositions and modifications of the arguments therein. Under additional assumptions, we obtain a localization result at the bottom of the spectrum.

Authors: Omar Hurtado (University of California, Irvine)

B4.1 Time: Saturday (11/4) 03:45 pm - 04:15 pm

Title: Geometric Borg's Theorem in arbitrary dimensions

Presenter: Wencai Liu

Affiliation: Texas A&M University

Abstract: The classical Borg's theorem states that for a one-dimensional periodic Schrodinger operator $\Delta + V$, the real-valued potential V is constant if and only if $\Delta + V$ has no spectral gaps. It is well-known that the analogue of Borg's theorem in higher dimensions does not hold. In this talk, I will discuss the geometric reinterpretation of Borg's theorem and the recent proof of this geometric version in arbitrary dimension.

Authors: Wencai Liu (Texas A&M University)

B4.2 Time: Saturday (11/4) 04:15 pm - 04:45 pm

Title: Bloch Discriminants

Presenter: Frank Sottile

Affiliation: Texas A&M University

Abstract: For a given a periodic graph G, there is a finite-dimensional parameter space encoding all possible edge weights and potentials. For each point in this parameter space, one may consider the corresponding Bloch variety and its various features (critical points and values, band gaps, singularities, etc.) Understanding/classifying how these features vary and change at different points in the parameter space is referred to as determining the geography of parameter space, and is a notoriously hard yet fundamental question considered in real algebraic geometry. In this talk, I will discuss this classification for a few diatomic graphs, and why this question for Bloch varieties is interesting from the perspective of real algebraic geometry. For spectral theory, this recovers the well-known counterexample of Filonov and Kachkovskiy to optimistic hopes for critical points of Bloch varieties, while providing the context of the operators with other parameters on the same graph. This is joint work with Margaret Regan and Simon Telen.

Authors: Margaret Regan (College of the Holy Cross), Frank Sottile (Texas A&M University), Simon Telen (MPI-MiS, Leipzig)

B4.3 Time: Sunday (11/5) 09:45 am - 10:15 am

Title: Closure of bulk spectral gaps for topological insulator with general edges

Presenter: Xiaowen Zhu

Affiliation: University of Washington

Abstract: Topological insulators are materials that have unique physical properties due to their non-trivial topological invariants (the Chern number). One of the most notable consequences of a topological insulator is that they behave like insulators in the bulk and conductors at the edge. Or mathematically speaking, the bulk spectral gaps close and the protected edge states emerge, which is known as the bulk-edge correspondence. In this talk, I will start with the definition of chern number and discuss closure of bulk spectral gaps for topological insulators with general edges. The talk is based on a joint work with Alexis Drouot.

Authors: Alexis Drouot (University of Washington) and Xiaowen Zhu (University of Washington)

B4.4 Time: Sunday (11/5) 10:15 am - 10:45 am

Title: Johnson-Schwartzman gap labelling and applications

Presenter: Iris Emilsdottir

Affiliation: Rice University

Abstract: Gap labelling involves identifying a set of labels for the spectral gaps on dynamically defined operators. Our focus will be on one-dimensional Schrödinger operators, where Johnson's theorem can be used to find those labels via the Schwartzman homomorphism. After a brief introduction we will discuss several recent classifications of Schwartzman groups and their applications including answering a question posed by D-F-Z regarding the Jacobi operator defined by the doubling map.

Authors: Iris Emilsdottir

B5.1 Time: Sunday (11/5) 11:00 am - 11:30 am

Title: Defect states in the continuum of Bernal stacked graphene

Presenter: Stephen P. Shipman

Affiliation: Louisiana State University at Baton Rouge

Abstract: AB-stacked bi-layer graphene admits defect states in the continuum. This is possible despite the absence of a symmetry operator and is due to the algebraic reducibility of the Fermi surface. The defect can be localized to just two sites, which is a special feature of graphene.

Authors: Daniel Massatt, Stephen P. Shipman, Ilya Vekhter, Justin Wilson: LSU

B5.2 Time: Sunday (11/5) 11:30 am - 12:00 pm

Title: Operators, Polytopes and Toric Geometry

Presenter: Jordy Lopez Garcia

Affiliation: Texas A&M University

Abstract: Bloch varieties arise in the spectral theory of Schrödinger operators on periodic graphs. For the square lattice, Bättig constructed a toric compactification of the Bloch variety and classified its singularities. Additionally, he constructed an infinite-dimensional vector bundle over this compactified variety and rewrote the original spectral problem on different coordinate patches. In this talk, we give recent developments of this bundle construction that apply to more general periodic graphs. This is joint work with Matt Faust and Frank Sottile.

Authors: Matthew Faust (Texas A&M University), Jordy Lopez Garcia (Texas A&M University) and Frank Sottile (Texas A&M University)

B5.3 Time: Sunday (11/5) 12:00 pm - 12:30 pm

Title: Exotic Eigenvalues for Quantum Graphs with Shrinking Edges

Presenter: Marshall King

Affiliation: Texas A&M University

Abstract: Consider the quantum graph made up of an edge of length $\varepsilon > 0$ connected by a central vertex to an edge of length 1. Depending on the vertex conditions, as $\varepsilon \to 0$, the negative eigenvalues of the Laplacian on this graph may tend towards $-\infty$. It would be reasonable to expect this to occur at a rate proportional to ε^{-1}, and this is indeed the case for some choices of vertex conditions. However, for particular choices of vertex conditions, the Laplacian has eigenvalues which tend towards $-\infty$ at the rate $\varepsilon^{-2/3}$ instead. This fractional rate is unexpected given the lack of any fractional relations in the problem. Even more unexpected is the fact that this behavior is not exclusive to this example graph. This is the only such fractional rate observed for eigenvalues of the Laplacian, including among more complicated examples of quantum graphs with shrinking edges. This is joint work with Gregory Berkolaiko and Denis Borisov.

Authors: Marshall King (Texas A&M University), Gregory Berkolaiko (Texas A&M University), and Denis I. Borisov (Institute of Mathematics UFRC RAS)

B5.4 Time: Sunday (11/5) 12:30 pm - 01:00 pm

Title: Norm-resolvent convergence for Neumann Laplacians on manifolds thinning to graphs

Presenter: Yuliia Yershova

Affiliation: Texas A&M University

Abstract: Spectral convergence of Neumann Laplacians A_ε on thin manifolds to graph Laplacians on corresponding metric graph G (when $\varepsilon \to 0$) with certain matching conditions at the vertices is widely studied. In the present talk we are interested in the so called "resonant case", when the vertex and edge volumes of the thin structure are of the same order. Resonant limiting matching conditions

in this case appear to be non-trivial, in particular they depend on the spectral parameter z. Thus the limiting self-adjoint operator A turns out to be the Strauss dilation of the corresponding generalized resolvent. We will be concerned with the analysis of this self-adjoint operator. In particular, we will show that its spectral properties blend together those of graph Laplacians with δ and δ'-type matching conditions.

Authors: Alexander Kiselev and Kirill Cherednichenko (University of Bath), Yuliia Yershova (Texas A&M University)

MS13: Recent Developments in Numerical Methods for PDEs and Applications

Organizers: Wei Guo (Texas Tech) and Chunmei Wang (University of Florida)
Time: Saturday (11/4) 01:30 pm - 03:30 pm, Saturday (11/4) 03:45 pm - 04:45 pm, Sunday (11/5) 09:45 am - 10:45 am, Sunday (11/5) 11:00 am - 01:00 pm
Venue: Griffin 144

B3.1 Time: Saturday (11/4) 01:30 pm - 02:00 pm

Title: Bound-Preserving Discontinuous Galerkin Solutions for Compressible Two-Phase Flows

Presenter: Beatrice Riviere

Affiliation: Rice University

Abstract: It is well known that discontinuous Galerkin approximation of multiphase flows in porous media yield numerical saturations that exhibit overshoot and undershoot phenomena in the neighborhood of the front. In this talk, we formulate flux limiters, which eliminate overshoot and undershoot phenomena when combined with slope limiters. Simulations of compressible flows that take into account heterogeneity, gravity and anisotropy show the robustness of the proposed method.

Authors: Sarraf Joshaghani (Ansys) and Beatrice Riviere (Rice University)

B3.2 Time: Saturday (11/4) 02:00 pm - 02:30 pm

Title: A Symbolic Approach for Scientific Machine Learning

Presenter: Haizhao Yang

Affiliation: University of Maryland College Park

Abstract: Machine learning has revolutionized computational science and engineering with impressive breakthroughs, e.g., making the efficient solution of high-dimensional computational tasks feasible and advancing domain knowledge via scientific data mining. This leads to an emerging field called scientific machine learning. In this talk, we introduce a new method for a symbolic approach to solving scientific machine learning problems. This method seeks interpretable learning outcomes in the space of functions with finitely many analytic expressions and, hence, this methodology is named the finite expression method (FEX). It is proved in approximation theory that FEX can avoid the curse of dimensionality in discovering high-dimensional complex systems. As a proof of concept, a deep reinforcement learning method is proposed to implement FEX for learning the solution of high-dimensional PDEs and learning the governing equations of raw data.

Authors: Zhongyi Jiang (University of Delaware), Senwei Liang (Lawrence Berkeley National Laboratory), Chunmei Wang (University of Florida), Haizhao Yang(University of Maryland College Park)

B3.3 Time: Saturday (11/4) 02:30 pm - 03:00 pm

Title: The reinterpreted discrete fracture model

Presenter: Yang Yang

Affiliation: Michigan Technological University

Abstract: In this talk, we propose a novel discrete fracture model for flow simulation of fractured porous media containing flow blocking barriers on non-conforming meshes. The methodology of the approach is to modify the traditional Darcy's law into the hybrid-dimensional Darcy's law where fractures and barriers are represented as Dirac-δ functions contained in the permeability tensor and resistance tensor, respectively. As a natural extension of the previous discrete fracture model for highly conductive fractures, this model is able to account for the influence of both highly conductive fractures and blocking barriers accurately on non-conforming meshes. The local discontinuous Galerkin (LDG) method is employed to accommodate the form of the hybrid-dimensional Darcy's law and the nature of the pressure/flux discontinuity. The performance of the model is demonstrated by several numerical tests.

Authors: Ziyao Xu (University of Notre Dame)

B3.4 Time: Saturday (11/4) 03:00 pm - 03:30 pm

Title: Friedrichs Learning for PDEs

Presenter: Chunmei Wang

Affiliation: University of Florida

Abstract: This speaker will discuss Friedrichs learning as a novel deep learning methodology that can learn the weak solutions of PDEs via a minmax formulation, which transforms the PDE problem into a minimax optimization problem to identify weak solutions. The name "Friedrichs learning" is for highlighting the close relationship between our learning strategy and Friedrichs theory on symmetric systems of PDEs. The weak solution and the test function in the weak formulation are parameterized as deep neural networks in a mesh-free manner, which are alternately updated to approach the optimal solution networks approximating the weak solution and the optimal test function, respectively. Extensive numerical results indicate that our mesh-free method can provide reasonably good solutions to a wide range of PDEs defined on regular and irregular domains in various dimensions, where classical numerical methods such as finite difference methods and finite element methods may be tedious or difficult to be applied.

Authors: Fan Chen (Shanghai Jiaotong University), Jianguo Huang(Shanghai Jiaotong University), Chunmei Wang (University of Florida), Haizhao Yang (University of Maryland College Park)

B4.1 Time: Saturday (11/4) 03:45 pm - 04:15 pm

Title: The Runge–Kutta discontinuous Galerkin method with compact stencils for hyperbolic conservation laws

Presenter: Zheng Sun

Affiliation: The University of Alabama

Abstract: In this talk, we present a new type of Runge–Kutta (RK) discontinuous Galerkin (DG) method for solving hyperbolic conservation laws. Compared with the original RKDG method, the new method features improved compactness and allows simple boundary treatment. The key idea is to hybridize two different spatial operators in an explicit RK scheme, utilizing local projected derivatives for inner RK stages and the usual DG spatial discretization for the final stage only.

Limiters are applied only at the final stage for the control of spurious oscillations. We also explore the connections between our method and Lax–Wendroff DG schemes and ADER-DG schemes. Numerical examples are given to confirm that the new RKDG method is as accurate as the original RKDG method, while being more compact, for problems including two-dimensional Euler equations for compressible gas dynamics.

Authors: Qifan Chen (The Ohio State University), Zheng Sun (The University of Alabama) and Yulong Xing (The Ohio State University)

B4.2 Time: Saturday (11/4) 04:15 pm - 04:45 pm

Title: Noise-robust Deep Direct Sampling via Transformers

Presenter: Shuhao Cao

Affiliation: UMKC

Abstract: In this talk, we shall present a study on a Transformer-based deep direct sampling method proposed for electrical impedance tomography, a well-known severely ill-posed nonlinear boundary value inverse problem. By evaluating the learned inverse operator using an end-to-end pipeline, a real-time reconstruction of the conductivity can be achieved. However, the robustness to noises in this approach relies on including specifically designed training data with clean output (conductivity) with noisy input (harmonic extensions of noisy boundary data). In this study, we shall propose an algorithm based on the Denoising Diffusion Probabilistic Models (DDPM), to learn how the nonlinear inverse operator's outputs are affected by the noise. Under moderate assumptions on the priors, the evaluation will achieve equally good reconstruction with input samples with 20% noise and those with 0% noise.

Authors: Shuhao Cao (UMKC) and Long Chen (UCI) and Ruchi Guo (CUHK)

B4.3 Time: Sunday (11/5) 09:45 am - 10:15 am

Title: Numerical analysis of a hybrid method for radiation transport

Presenter: Andrés Felipe Galindo-Olarte

Affiliation: University of Texas at Austin/ODEN institute

Abstract: In this talk, we will present rigorous error estimates for a hybrid method introduced in *hauck2013collision* for solving the time-dependent radiation transport equation (RTE). The method relies on a splitting of the kinetic distribution function for the radiation into uncollided and collided components. A high-resolution method (in angle) is used to approximate the uncollided components and a low-resolution method is used to approximate the the collided component. After each time step, the kinetic distribution is reinitialized to be entirely uncollided. For this analysis, we consider a mono-energetic problem on a periodic domain, with constant material cross-sections of arbitrary size. To focus the analysis, we assume the uncollided equation is solved exactly and the collided part is approximated in angle via a spherical harmonic expansion (P_N method). Using a non-standard set of semi-norms, we obtain estimates of the form $C(\varepsilon, \sigma, \Delta t)N^{-s}$ where $s \geq 1$ denotes the regularity of the solution in angle, ε and σ are scattering parameters, Δt is the time-step before reinitialization, and C is a complicated function of ε, σ, and Δt. These estimates involve analysis of the multiscale RTE that includes, but necessarily goes beyond, usual spectral analysis. We also compute error estimates for the monolithic P_N method with the same resolution as the collided part in the hybrid. Our results highlight the benefits of the hybrid approach over the monolithic discretization in both highly scattering and streaming regimes.

Authors: Andrés Felipe Galindo Olarte (University of Texas Austin/ODEN institute) , Victor DeCaria (Oak Ridge National Laboratory) and Cory Hauck (Oak Ridge National Laboratory and University of Tennessee)

B4.4 Time: Sunday (11/5) 10:15 am - 10:45 am

Title: Large Eddy Simulation for the quasi-geostrophic equations

Presenter: Lander Besabe

Affiliation: University of Houston

Abstract: In this talk, we will explore the utilization of various nonlinear differential low-pass filters for the Large Eddy Simulation (LES) of the quasi-geostrophic equations. Our goal is to assess the accuracy of the filters by analyzing time-averaged fields of interest within the framework of the classical double-gyre wind forcing experiment. Moreover, we will introduce some preliminary results of its extension for the stratified two-layer quasi-geostrophic equations (2LQGE). We will then propose an efficient segregated algorithm using Finite Volume methods for 2LQGE. Lastly, we will also present manufactured numerical tests to show the rate of convergence of the method for solving steady state solutions of the said model. These results could enhance our understanding of large-scale geophysical fluids and contribute to the development of more robust numerical models for ocean flows.

Authors: Lander Besabe (University of Houston), Michele Girfoglio (SISSA, International School for Advanced Studies), Annalisa Quaini (University of Houston), and Gianluigi Rozza(SISSA, International School for Advanced Studies)

B5.1 Time: Sunday (11/5) 11:00 am - 11:30 am

Title: Discontinuous Galerkin methods for network patterning phase-field models

Presenter: Yuan Liu

Affiliation: Wichita State University

Abstract: In this talk, we discuss a class of discontinuous Galerkin methods under the scalar auxiliary variable framework (SAV-DG) to solve a biological patterning model in the form of parabolic-elliptic partial differential equation system. In particular, mixed-type discontinuous Galerkin approximations are used for the spatial discretization, aiming to achieve a balance between the high resolution and computational cost. Second and third order backward differentiation formulas are considered under SAV framework for discrete energy stability. Numerical experiments are provided to show the effectiveness of the fully discrete schemes and the governing factors of patterning formation.

Authors: Lei Yang (University of Science and Technology of China), Yuan Liu (Wichita State University), Yan Jiang (University of Science and Technology of China) and Mengping Zhang (University of Science and Technology of China)

B5.2 Time: Sunday (11/5) 11:30 am - 12:00 pm

Title: Realizability-Preserving DG-IMEX Method for a Two-Moment Model of Special Relativistic Transport

Presenter: Joseph Hunter

Affiliation: Ohio State University

Abstract: Special relativistic transport models are important for describing the transport of neutrinos, with applications to supernovae and gravitational waves. We study a two-moment model that evolves the Eulerian moments of a particle distribution function f. Due to physical bounds on the distribution function, $f \geq 0$, we want a numerical method which preserves these bounds on the evolved moments. Such moments are said to be realizable. The model is not closed in terms of the evolved moments, and thus requires a closure procedure. As a result of this, it is necessary to recover Lagrangian moments of f from the evolved Eulerian moments. The proposed realizability-preserving scheme uses the discontinuous Galerkin (DG) method to discretize space and uses an implicit-explicit (IMEX) time integration method. Moment realizability is preserved through the appropriate choice of numerical spatial and numerical energy fluxes. This yields a realizability-preserving timestep restriction for the IMEX method. In addition, we require the moment recovery process to be realizability-preserving, since the recovery process can be extended to the nonlinear solve required in the IMEX method.

Authors: Joseph Hunter (Ohio State University), Eirik Endeve (Oak Ridge National Laboratory), and Yulong Xing (Ohio State University)

B5.3 Time: Sunday (11/5) 12:00 pm - 12:30 pm

Title: A semi-implicit dynamical low-rank discontinuous Galerkin method for space homogeneous kinetic equations

Presenter: Peimeng Yin

Affiliation: University of Texas at El Paso

Abstract: Dynamical low-rank approximation (DLRA) is an emerging tool for reducing computational costs and provides memory savings when solving high-dimensional problems. In this work, we propose and analyze a semi-implicit dynamical low-rank discontinuous Galerkin (DLR-DG) method for the space homogeneous kinetic equation with a relaxation operator, modeling the emission and absorption of particles by a background medium. Both DLRA and the DG scheme can be formulated as Galerkin equations. To ensure their consistency, a weighted DLRA is introduced so that the resulting DLR-DG solution is a solution to the fully discrete DG scheme in a subspace of the classical DG solution space. Similar to the classical DG method, we show that the proposed DLR-DG method is well-posed. We also identify conditions such that the DLR-DG solution converges to the equilibrium. Numerical results are presented to demonstrate the theoretical findings.

Authors: Eirik Endeve (Oak Ridge National Laboratory), Cory Hauck (Oak Ridge National Laboratory), and Stefan Schnake (Oak Ridge National Laboratory) and Peimeng Yin (University of Texas at El Paso)

B5.4 Time: Sunday (11/5) 12:30 pm - 01:00 pm

Title: A fourth-order conservative semi-Lagrangian finite volume WENO scheme without operator splitting for kinetic and fluid simulations

Presenter: Nanyi Zheng

Affiliation: University of Delaware

Abstract: In this talk, we present a fourth-order conservative semi-Lagrangian (SL) finite volume (FV) weighted essentially non-oscillatory (WENO) scheme without operator splitting for two-dimensional linear transport equations with applications of kinetic models including the nonlinear Vlasov-Poisson system, the guiding center Vlasov model and the incompressible Euler equation in the vorticity-stream function formulation. To achieve fourth-order accuracy in space, two main ingredients are proposed in the SL FV formulation. Firstly, we introduce a so-called cubic-curved quadrilateral upstream cell and applying an efficient clipping method to evaluate integrals on upstream cells. Secondly, we construct a new WENO reconstruction operator, which recovers a P^3

polynomial from neighboring cell averages. Mass conservation is accomplished with the mass conservative nature of the reconstruction operator and the SL formulation. A positivity-preserving limiter is applied to maintain the positivity of the numerical solution wherever appropriate. For nonlinear kinetic models, the SL scheme is coupled with a fourth-order Runge-Kutta exponential integrator for high-order temporal accuracy. Extensive bench marks are tested to verify the designed properties.

Authors: Nanyi Zheng (University of Delaware), Xiaofeng Cai (Beijing Normal University), Jing-Mei Qiu (University of Delaware) and Jianxian Qiu (Xiamen University)

MS14: Nonlinear algebra in applications

Organizers: Julia Lindberg (The University of Texas at Austin) and Jordy Lopez Garcia (Texas A&M University)
Time: Friday (11/3) 03:00 pm - 05:00 pm, Saturday (11/4) 09:45 am - 11:45 am
Venue: Griffin 201

B1.1 Time: Friday (11/3) 03:00 pm - 03:30 pm

Title: Geometry and the complexity of matrix multiplication: recent developments

Presenter: J.M. Landsberg

Affiliation: Texas A&M University

Abstract: I will discuss recent developments that provide a path for proving new upper bounds on the complexity of matrix multiplication using methods from algebraic geometry.

Authors: Austin Conner (Harvard), Hang (Amy) Huang (Auburn), J.M. Landsberg (TAMU)

B1.2 Time: Friday (11/3) 03:30 pm - 04:00 pm

Title: The principal minor map

Presenter: Abeer Al Ahmadieh

Affiliation: Georgia Institute of Technology

Abstract: The principal minor map takes an $n \times n$ square matrix and maps it to the 2^n-length vector of its principal minors. In this talk, I will describe the fiber and the image of this map over any field $\mathbb{F}$. In 1986, Loewy proposed a condition that was sufficient to ensure that the fiber of the principal minor map is a single point up to diagonal equivalence. In this talk, I will provide a necessary and sufficient condition for the fiber to be a single point up to diagonal equivalence. I will also describe the image of the space of complex matrices using a characterization of determinantal representations of multiaffine polynomials, based on the factorization of their Rayleigh differences. Using these techniques, I will give equations and inequalities that characterize the images of the spaces of real and complex symmetric and Hermitian matrices. This is based on joint work with Cynthia Vinzant.

Authors: Abeer Al Ahmadieh (Georgia Institute of Technology) and Cynthia Vinzant (University of Washington)

B1.3 Time: Friday (11/3) 04:00 pm - 04:30 pm

Title: Maximal Border Subrank Tensors

Presenter: Chia-Yu Chang

Affiliation: Texas A&M University

Abstract: Subrank and border subrank were introduced by Strassen. The rank and border rank of a generic tensor are the same and equal to the maximal border rank. However, we know less about the behavior of the subrank and border subrank. In this talk, we will introduce subrank and border subrank. Then we will give a lower bound of the dimension of the set of maximal border subrank tensors.

Authors: Chia-Yu Chang (Texas A&M University)

B1.4 Time: Friday (11/3) 04:30 pm - 05:00 pm

Title: Moment Estimation of Nonparametric Mixtures Through Implicit Tensor Decomposition

Presenter: Joe Kileel

Affiliation: University of Texas at Austin

Abstract: In this talk I will present computational methods to estimate certain statistical models from data samples. The models are conditionally-independent mixture models, and they cover a wide range of applications. The methods are based on tensor decomposition and completion, although—crucially—they avoid the explicit formation of tensors, which efficiency in high dimensions. Time permitting, I'll also discuss algebraic varieties underlying the problem. This is based on joint works with Yifan Zhang, and with Yulia Alexandr and Bernd Sturmfels.

Authors: Joe Kileel (UT Austin), Yifan Zhang (UT Austin), Yulia Alexandr (UC Berkeley), Bernd Sturmfels (MPI Leipzig)

B2.1 Time: Saturday (11/4) 09:45 am - 10:15 am

Title: Welschinger Signs and the Wronskii map

Presenter: Frank Sottile

Affiliation: Texas A&M University

Abstract: A general real rational plane curve C of degree d has $3(d-2)$ flexes and $(d-1)(d-2)/2$ complex double points. Those double points lying in $\mathbb{R}P^2$ are either nodes or solitary points. The Welschinger sign of C is $(-1)^s$, where s is the number of solitary points. When all flexes of C are real, its parameterization comes from a point on the Grassmannian under the Wronskii map, and every parameterized curve with those flexes is real (this is the Mukhin-Tarasov-Varchenko Theorem). Thus to C we may associate the local degree of the Wronskii map, which is also 1 or -1. My talk will discuss work with Brazelton towards a possible conjecture that that these two signs associated to C agree, and the challenges to gathering evidence for this.

Authors: Frank Sottile (Texas A&M University)

B2.2 Time: Saturday (11/4) 10:15 am - 10:45 am

Title: Border rank bounds for $GL(V)$-invariant tensors arising from matrices of constant rank

Presenter: Derek Wu

Affiliation: Texas A&M University

Abstract: We prove border rank bounds for a class of $GL(V)$-invariant tensors corresponding to a space of matrices of constant rank that are $GL(V)$-invariant in a $GL(V)$-invariant space $V \otimes U \otimes W$, where U and W are $GL(V)$-modules. In particular we prove lower bounds for tensors in $\mathbb{C}^l \otimes \mathbb{C}^m \otimes \mathbb{C}^n$ that are not 1_A-generic, where no nontrivial bounds were known, and also when $l, m \ll n$, where previously only bounds for unbalanced matrix multiplication were known.

Authors: Derek Wu (Texas A&M University)

B2.3 Time: Saturday (11/4) 10:45 am - 11:15 am

Title: Combinatorial Aspects of Polynomials with Lorentzian Signature

Presenter: Papri Dey

Affiliation: Georgia Institute of Technology

Abstract: Over the past decade, there has been a notable effort to fuse the techniques of algebraic geometry and combinatorics, crafting a comprehensive framework for addressing long-standing conjectures in theoretical computer science, and matroid theory pertaining to unimodality and log-concavity. This endeavor includes an exploration of Lorentzian polynomials, also known as completely log-concave or strongly log-concave polynomials, which establishes a bridge between discrete and continuous convexity. We study a natural generalization to the remarkable class of Lorentzian polynomials, referred to as polynomials with Lorentzian signature (PLS) over convex cones. In this talk, I will discuss some key characteristics of this polynomial class, and using its connection with hereditary polynomials associated with simplicial complexes, I shall focus on its applications, particularly in the context of optimization.

Authors: Greg Blekherman (Georgia Tech), Papri Dey (Georgia Tech)

B2.4 Time: Saturday (11/4) 11:15 am - 11:45 am

Title: Betti Tables of the 2×2 permanents of a $2 \times n$ matrix

Presenter: Hang Huang

Affiliation: Auburn University

Abstract: I will discuss how to describe the minimal free resolution for the 2×2 permanents of a generic matrix M. In contrast to the case of 2×2 determinants, the 2×2 permanents define an ideal I which is neither prime nor Cohen-Macaulay. From an applied standpoint, permanental ideals play a major role in computational complexity theory. The starting point combines works of Laubenbacher-Swanson on the Gröbner basis of an ideal of 2×2 permanents of a generic matrix with the previous work connecting the initial ideal of 2×2 permanents to a simplicial complex. The main technical tool is a spectral sequence arising from the Bernstein-Gelfand-Gelfand correspondence.

Authors: Hang Huang(Auburn University), Henry K. Schenck (Auburn University), Fulvio Gesmundo (University of Saarland), Jerzy Weyman (Instytut Matematyki, Jagiellonian University)

MS15: Combinatorial commutative algebra

Organizers: Anton Dochtermann (Texas State University)
Time: Saturday (11/4) 01:30 pm - 03:30 pm, Saturday (11/4) 03:45 pm - 04:45 pm, Sunday (11/5) 09:45 am - 10:45 am
Venue: Griffin 305

B3.1 Time: Saturday (11/4) 01:30 pm - 02:00 pm

Title: Scarf complexes of graphs and their powers

Presenter: Tai Ha

Affiliation: Tulane University

Abstract: We examine Scarf complexes of the edge ideal of a graph and its powers. We give a concrete description of the Scarf complex of any tree. For a general graph, we give a recursive construction for its Scarf complex based on Scarf complexes of induced subgraphs. We also characterize when Scarf complexes of the edge ideal of a graph and its powers support their minimal free resolutions.

Authors: Tai Ha (Tulane University)

B3.2 Time: Saturday (11/4) 02:00 pm - 02:30 pm

Title: Minimal Free Resolutions of Numerical Semigroup Algebras Via Apery Specializations

Presenter: Aleksandra Sobieska

Affiliation: University of Wisconsin

Abstract: Numerical semigroups with multiplicity m are parameterized by integer points in a polyhedral cone C_m. For the toric ideal of any such semigroup, this talk will present a free resolution with the property that the structure of the resolution is almost identical for any two semigroups contained in the interior of a fixed face of C_m. This resolution is minimal when the semigroup is maximal embedding dimension, i.e., contained in the interior C_m. One can further use this resolution to show the uniformity of the Betti numbers of all toric ideals defined by semigroups in the same face of C_m.

Authors: Aleksandra Sobieska (University of Wisconsin)

B3.3 Time: Saturday (11/4) 02:30 pm - 03:00 pm

Title: Minimal resolutions of lattice ideals

Presenter: Yupeng Li

Affiliation: Duke University

Abstract: In this talk, we construct canonical minimal free resolution of an arbitrary co-artinian lattice ideal over the polynomial ring over any field whose characteristic is 0 or any but finitely many positive primes. The differential has a closed-form combinatorial description as a sum over lattice paths in $\mathbb{Z}^n$ of weights that come from sequences of faces in simplicial complexes indexed by lattice points. Over a field of any characteristic, a non-canonical but simpler resolution is constructed by selecting choices of higher-dimensional analogues of spanning trees along lattice paths. These constructions generalize sylvan resolutions for monomial ideals by lifting them equivariantly to lattice modules. Joint work with Ezra Miller and Erika Ordog.

Authors: Ezra Miller (Duke) and Erika Order (Texas A&M) and Yupeng Li (Duke)

B3.4 Time: Saturday (11/4) 03:00 pm - 03:30 pm

Title: Unipotent Numerical Semigroups

Presenter: Naufil Sakran

Affiliation: Tulane University

Abstract: The talk intends to introduce the generalization of the theory of numerical semigroups to the theory of unipotent numerical semigroups. Numerical semigroups arise naturally in the field of commutative algebra. It has the advantage of being simple, yet powerful enough to be used in classification problems. Application of these objects ranges from providing tests to determine "especially nice" rings and local domains to algebraic coding theory and singularity theory. The aim of this research is to extend the theory and introduce new tools so that they can be used in broader contexts. In our work, we extend the basic invariants of the classical theory to our proposed

unipotent setting, enabling us to define ideals, blowups, and unipotent Arf semigroups. We show that the blowup and unipotent Arf closure commute in the unipotent setting, which indicates that we have a good foundation for future progress. In addition, in our setting, we generalize the Wilf Conjecture and compare it with other known generalizations.

Authors: Naufil Sakran (Tulane)

B4.1 Time: Saturday (11/4) 03:45 pm - 04:15 pm

Title: Alexander Duals of Symmetric Simplicial Complexes and Stanley-Reisner Ideals

Presenter: Ayah Almousa

Affiliation: University of Minnesota

Abstract: Given an ascending chain of Sym-invariant squarefree monomial ideals $\{I_n\}$, we study the corresponding chain of Alexander duals $\{I_n^\vee\}$. Using a novel combinatorial tool, which we call avoidance up to symmetry, we provide an explicit description of the minimal generating set up to symmetry in terms of the original generators. Combining this result with methods from discrete geometry, this enables us to show that the number of orbit generators of $I_n^\vee$ is given by a polynomial in n for sufficiently large n. The same is true for the number of orbit generators of minimal degree, this degree being a linear function in n eventually. The former result implies that the number of Sym-orbits of primary components of I_n grows polynomially in n for large n. As another application, we show that the number of i-dimensional faces of the associated Stanley-Reisner complexes of I_n is also given by a polynomial in n for large n. This is joint work with Katie Bruegge (Kentucky), Martina Junke (Osnabruck), Uwe Nagel (Kentusky), and Sasha Pevzner (Minnesota).

Authors: Ayah Almousa (Wisconsin), Katie Bruegge (Kentucky), Martina Junke (Osnabruck), Uwe Nagel (Kentusky), and Sasha Pevzner (Minnesota)

B4.2 Time: Saturday (11/4) 04:15 pm - 04:45 pm

Title: Shellability of symmetric spaces and Bruhat orders

Presenter: Nestor Diaz

Affiliation: Tulane University

Abstract: A symmetric space is a homogeneous space G/K where G is a reductive (complex) algebraic group and K is the fixed-point subgroup of an algebraic involution $\theta : G \to G$. As in the particular examples of flag varieties, Borel subgroup orbits in other symmetric spaces are combinatorially parametrized and equipped with a closure-containment (or Bruhat) order which possesses nice order-theoretic properties. One poset property is called shellability, which implies that a simplicial complex associated to the poset has the homotopy type of a wedge of spheres. It has been known since the 1980's that Bruhat orders of (parabolic quotients of) Coxeter groups are shellable, and these results have been extended to other symmetric spaces more recently. We will discuss shellability of the Bruhat order for the symmetric space $GL_{p+q}/GL_p \times GL_q$ (joint work with Aram Bingham).

Authors: Nestor Diaz (Tulane University) and Aram Bingham

B4.3 Time: Sunday (11/5) 09:45 am - 10:15 am

Title: K-orbit closures and Hessenberg varieties

Presenter: Mahir Can

Affiliation: Tulane University

Abstract: In this talk we will discuss a special family of Hessenberg varieties in relation with K-orbit closures in flag varieties, where K is the subgroup GL(k)xGL(n-k) of GL(n). Our goal is to explain how K-orbits can be used for understanding the geometry of Hessenberg varieties of semisimple operators with two eigenvalues. This talk is based on my joint work with Martha Precup, John Shareshian, and Ozlem Ugurlu.

Authors: Mahir Can (Tulane), Martha Precup (Washington U), John Shareshian (Washington U), and Ozlem Ugurlu (Saint Louis U)

B4.4 Time: Sunday (11/5) 10:15 am - 10:45 am

Title: On the Nilpotent Subsemigroups of M_n and MSp_n

Presenter: Corey Wolfe

Affiliation: Tulane University

Abstract: This talk will discuss the nilpotent subsemigroups of the Borel semigroups of M_n and MSp_n. While the nilpotent subsemigroup of the Borel submonoid of M_n proves to be irreducible, the situation differs when dealing with MSp_n. Our objective is to enumerate the irreducible components of $\overline{BSp_n}^{nil}$ through a combinatorial approach, introducing a partial order on symplectic arc diagrams that is equivalent to the Bruhat-Chevalley-Renner order on symplectic upper triangular matrices. Furthermore, we establish a correspondence between a subset of maximal elements and Motzkin paths featuring colored plateaus.

Authors: Corey Wolfe (Tulane)

MS16: Combinatorial algebraic geometry and rigidity theory

Organizers: Daniel Irving Bernstein (Tulane) and Kalina Mincheva (Tulane)
Time: Saturday (11/4) 09:45 am - 11:45 am, Saturday (11/4) 01:30 pm - 03:30 pm
Venue: Griffin 203

B2.1 Time: Saturday (11/4) 09:45 am - 10:15 am

Break/Discussion

B2.2 Time: Saturday (11/4) 10:15 am - 10:45 am

Title: Statistics via tropical geometry

Presenter: Jidong Wang

Affiliation: UT Austin

Abstract: Tropical geometry is the algebraic geometry of piecewise linear functions, which are also the building blocks of many statistical models. In this talk, I will share how a geometric point of view can help obtain non-obvious results meaningful for statisticians. I will discuss region counting for arrangements of tropical hypersurfaces, which are generalizations of real hyperplane arrangements. I will share a lower bound for the number of vertices of Minkowski sums of generic polytopes, which can be obtained by understanding the topology of complete intersections of generic tropical hypersurfaces. Those results can be interpreted in terms of complexity of PL functions. Finally, I will discuss a decomposition theorem for PL functions and the problem of finding canonical representatives for virtual polytopes.

Authors: Jidong Wang (UT Austin), Ngoc Tran (UT Austin)

B2.3 Time: Saturday (11/4) 10:45 am - 11:15 am

Title: From configurations on graphs to moduli spaces of (tropical) curves

Presenter: Christin Bibby

Affiliation: LSU

Abstract: The map $\mathcal{M}_{g,n} \to \mathcal{M}_g$ on moduli spaces of genus g algebraic curves, given by forgetting marked points, is a fibration whose fiber is a configuration space of a surface. One can then "in principle" compute the cohomology of $\mathcal{M}_{g,n}$ using the Serre spectral sequence. We present a tropical analogue of this spectral sequence, manifesting as a graph complex and featuring the cohomology of compactified configuration spaces on graphs. We use this to obtain new calculations in the top weight cohomology of the moduli spaces $\mathcal{M}_{2,n}$ and $\mathcal{M}_{3,n}$.

Authors: Christin Bibby (LSU), Melody Chan (Brown), Nir Gadish (University of Michigan), and Claudia He Yun (University of Michigan)

B2.4 Time: Saturday (11/4) 11:15 am - 11:45 am

Title: Tropicalization in Extremal Combinatorics

Presenter: Greg Blekherman

Affiliation: Georgia Tech

Abstract: Abstract: Tropicalization has been frequently applied in algebraic geometry to give "combinatorial shadows" of complicated objects. But one can also tropicalize manifestly non-algebraic sets. If a set S is closed under coordinate-wise (Hadamard) multiplication then its tropicalization (in the sense of log-limits) is a closed convex cone. Valid linear inequalities on the tropicalization cone correspond to valid binomial inequalities on the original set S. I will give several examples of combinatorial sets, where tropicalization encodes interesting information (for instance, log-concavity of a sequence is given by binomial inequalities). An interesting phenomenon emerges: tropicalizations of interesting combinatorial objects are rational polyhedral cones. I do not have a good explanation for this, and would greatly benefit from audience's help.

Authors: Greg Blekherman (Georgia Tech) and Annie Raymond (University of Massachusetts, Amherst)

B3.1 Time: Saturday (11/4) 01:30 pm - 02:00 pm

Title: Global Minimization of Analytic Functions over Compact Domains

Presenter: Georgy Scholten

Affiliation: Sorbonne Université

Abstract: In this talk, we introduce a new method for minimizing analytic Morse functions over compact domains through the use of polynomial approximations. This is, in essence, an effective application of the Stone-Weierstrass Theorem, as we seek to extend a local method to a global setting, through the construction of polynomial approximants satisfying an arbitrary set precision in L-infty norm. The critical points of the polynomial approximant are computed exactly, using methods from computer algebra. Our Main Theorem states probabilistic conditions for capturing all local minima of the objective function f over the compact domain. We present a probabilistic method, iterative on the degree, in order to construct the lowest degree possible least-squares polynomial approximant of f to attain a desired precision over the domain. We then compute the critical points of the approximant and initialize local minimization methods on the objective function f at these points, in order to recover the totality of the local minima of f over the domain.

Authors: Mohab Safey El Din (Sorbonne Université), Georgy Scholten (Sorbonne Université), and Emmanuel Trélat (Sorbonne Université)

B3.2 Time: Saturday (11/4) 02:00 pm - 02:30 pm

Title: Higher rank tropical geometry and the variation of the demand

Presenter: Hernan Iriarte

Affiliation: UT Austin

Abstract: In 2008, Paul Klemperer introduced a framework to study the demand of a family of agents based on interpreting their corresponding utility functions as tropical polynomials and exploiting the language of tropical geometry. In this talk we will show how the use of tropical geometry over the tropical semiring $(\mathbb{R}^n, +, \max_{\text{lex}})$ can be used to describe the change of demand as the preferences of the agent change. This is based on the study of tropical hypersurfaces on this particular tropical geometry. Joint work with Jaime Tobar.

Authors: Hernan Iriarte (UT Austin), Jaime Tobar (Universidad de Santiago de Chile)

B3.3 Time: Saturday (11/4) 02:30 pm - 03:00 pm

Title: Flag Matroids as Greedoids

Presenter: Nate Vaduthala

Affiliation: Tulane University

Abstract: Matroids can be seen as a combinatorial abstraction of linear subspaces, and in a similar manner flag matroids can be seen as a combinatorial abstraction of flags of linear subspaces. However, despite their name, flag matroids are not matroids but can be viewed as greedoids. In this talk, we will look at some properties and results that come from viewing flag matroids as greedoids.

Authors: Nate Vaduthala (Tulane University) and Daniel Irving Bernstein (Tulane University)

B3.4 Time: Saturday (11/4) 03:00 pm - 03:30 pm

Title: Singular matroid realization spaces

Presenter: Daniel Corey

Affiliation: University of Nevada, Las Vegas

Abstract: By Mnëv's universality theorem, every singularity type appears in the realization spaces of a rank 3 matroid. While the proofs of this theorem are constructive, the resulting matroids have large ground sets even for the simplest singularities. I will present recent joint work with Dante Luber (TU Berlin) where we show that, over the complex numbers, the realization spaces of rank 3 matroids on ≤ 11 elements are all smooth, but there are singular realization spaces for matroids on ≥ 12 elements. We use this result to show that the open Grassmannian is not schön in the sense of Tevelev.

Authors: Daniel Corey (University of Nevada, Las Vegas), Dante Luber (TU Berlin)

MS17: (Complex) analysis in differential equations

Organizers: John Treuer (University of California San Diego) and Wencai Liu (Texas A&M University)
Time: Saturday (11/4) 09:45 am - 11:45 am, Saturday (11/4) 01:30 pm - 03:30 pm
Venue: Griffin 304

B2.1 Time: Saturday (11/4) 09:45 am - 10:15 am

Title: Alexeev Generalized Hydrodynamic Equations for Turbulent Flows

Presenter: Alex Fedoseyev

Affiliation: Ultra Quantum Inc., Huntsville, Alabama, USA

Abstract: Generalized Hydrodynamic Equations (GHE) by Boris Alexeev (1994) have been derived from the Generalized Boltzmann Equation (GBE) that was obtained by the first principles from the chain of Bogolubov kinetic equations. The approximate analytical solution of GBE for turbulent flows in channel is presented. In distinction of the Navier-Stokes equations, the solution is a linear combination of the parabolic (laminar) and superexponential (turbulent) solutions. The Navier-Stokes equations does not have the superexponential solution. Solution compared well with the experimental data from Nicuradse (1932, Prandtl Lab) to Wei and Willmarth (1989). The numerical solution of GHE is presented for several complex turbulent flows: 3D driven cavity problem at Re = 3200 and 10,000, 2D backward facing step flow at Re = 132,000, flows in channels for Reynolds number from Re = 5000 to $Re = 10^6$, magnetohydrodyamic flows . Results for GHE model are reported and are in close agreement with the experiments by Koseff and Street (1984), Kim, Kline and Johnston (1980). These results present the explicit proof that the Alexeev generalized hydrodynamic theory (GHE and GBE) is in good agreement with experiments for turbulent flows.

Authors: Alex Fedoseyev

B2.2 Time: Saturday (11/4) 10:15 am - 10:45 am

Title: p-Skwarczyński distance

Presenter: Shreedhar Bhat

Affiliation: Texas A&M University

Abstract: We will discuss some of the new tools to better study the p-Bergman space (A^p). We also introduce a new distance on a bounded domain using the 'minimizer' functions on $A^p(\Omega)$. We discuss its invariance, completeness and other aspects related to it.

Authors: Shreedhar Bhat (Texas A&M University)

B2.3 Time: Saturday (11/4) 10:45 am - 11:15 am

Title: On partial differential equations of Waring's-problem form in several complex variables

Presenter: Qi Han

Affiliation: Texas A&M University-San Antonio

Abstract: In this talk, we study when some PDEs of Waring's-problem form can have entire solutions in $\mathbf{C}^n$ and further find these solutions for important cases including particularly $u_{z_1}^\ell + u_{z_2}^\ell + \cdots + u_{z_n}^\ell = u^\hbar$, which are (often said to be) PDEs of super-Fermat form if $\hbar = 0, \ell$ and an eikonal equation if $\ell = 2$ and $\hbar = 0$.

Authors: Qi Han (Texas A&M University-San Antonio)

B2.4 Time: Saturday (11/4) 11:15 am - 11:45 am

Title: The Levi Core

Presenter: John Treuer

Affiliation: University of California San Diego

Abstract: On a smooth, bounded pseudoconvex domain Ω in $\mathbb{C}^n$, to verify that Catlin's Property (P) holds for Ω, it suffices to check that it holds on the set of D'Angelo infinite type boundary points. We consider a recent construction due to Dall'Ara and Mongodi called the Levi core whose support is a subset of the infinite type points. We show that Property (P) holds for $b\Omega$ if and only if it holds for the support of the Levi core. Consequently, if Property (P) holds, then the $\overline{\partial}$-Neumann operator is compact.

Authors: John Treuer (University of California San Diego

B3.1 Time: Saturday (11/4) 01:30 pm - 02:00 pm

Title: The Diederich–Fornæss index and the $\bar{\partial}$-Neumann problem

Presenter: Bingyuan Liu

Affiliation: The University of Texas Rio Grande Valley

Abstract: A domain $\Omega \subset \mathbb{C}^n$ is said to be pseudoconvex if $-\log(-\delta(z))$ is plurisubharmonic in Ω, where δ is a signed distance function of Ω. The study of global regularity of $\bar{\partial}$-Neumann problem on bounded pseudoconvex domains is dated back to the 1960s. However, a complete understanding of the regularity is still absent. On the other hand, the Diederich–Fornæss index was introduced in 1977 originally for seeking bounded plurisubharmonic functions. Through decades, enormous evidence has indicated a relationship between global regularity of the $\bar{\partial}$-Neumann problem and the Diederich–Fornæss index. Indeed, it has been a long-lasting open question whether the trivial Diederich–Fornæss index implies global regularity. In this talk, we will introduce the backgrounds and motivations. The main theorem of the talk proved recently by Emil Straube and me answers this open question for $(0, n-1)$ forms.

Authors: Emil Straube (Texas A&M University) and Bingyuan Liu (The University of Texas Rio Grande Valley)

B3.2 Time: Saturday (11/4) 02:00 pm - 02:30 pm

Title: Modifications of the Levi Core

Presenter: Tanuj Gupta

Affiliation: Texas A&M University, College Station

Abstract: We construct a family of subdistributions of the Levi core $\mathfrak{C}(\mathcal{N})$ called modified Levi cores $\{\mathcal{M}\mathfrak{C}_{\mathcal{A}}\}_{\mathcal{A}}$ indexed over closed distributions $\mathcal{A}$ that contain the Levi null distribution $\mathcal{N}$ and are contained in the complex tangent bundle $T^{1,0}b\Omega$ of a smooth bounded pseudoconvex domain Ω. We show that Catlin's Property (P) holds on $b\Omega$ if and only if Property (P) holds on the support of one, and hence all, of the modified Levi cores. In $\mathbb{C}^2$, all of the modified Levi cores coincide. For a smooth bounded pseudoconvex complete Hartogs domain in $\mathbb{C}^2$ that satisfies Property (P), we show that its modified Levi core is trivial. This contrasts with $\mathfrak{C}(\mathcal{N})$, which can be nontrivial for such domains. This is a joint work with Emil J. Straube and John N. Treuer.

Authors: Tanuj Gupta (Texas A&M University, College Station), Emil J. Straube (Texas A&M University, College Station), and John N. Treuer (University of California San Diego)

B3.3 Time: Saturday (11/4) 02:30 pm - 03:00 pm

Title: Arithmetic phase transitions for one-dimensional quasiperiodic operators with monotone potentials

Presenter: Ilya Kachkovskiy

Affiliation: Michigan State University

Abstract: We consider a wide class of one-dimensional quasiperiodic Schrödinger operators with bounded and unbounded Lipschitz monotone potentials and establish sharp arithmetic transitions in the frequency: that is, the spectra of such operators are pure point on the set of energies with $\{E\colon L(E) > \beta(\alpha)\}$ and, for almost every phase, purely singular continuous on the set $\{E\colon L(E) < \beta(\alpha)\}$. Here, $L(E)$ is the Lyapunov exponent at the energy E and $\beta(\alpha) = \limsup_{n\to+\infty} \frac{\log q_{n+1}}{q_n}$ is the measure of irrationality of the frequency.

Authors: Svetlana Jitomirskaya (University of California, Irvine) and Ilya Kachkovskiy (Michigan State University)

B3.4 Time: Saturday (11/4) 03:00 pm - 03:30 pm

Title: On Irreducibility of the Bloch variety

Presenter: Matthew Faust

Affiliation: Texas A&M University

Abstract: Given a $\mathbb{Z}^2$-periodic graph G, the Schrodinger operator associated to G is a graph Laplacian with a potential. After a Floquet transform our operator can be represented by a finite matrix whose entries are Laurent polynomials. The vanishing set of this characteristic polynomial is the Bloch variety. Questions regarding the algebraic properties of this object are of interest in mathematical physics. We will focus our attention on the irreducibility of this variety. Understanding the irreducibility of the Bloch variety is important in the study of the spectrum of discrete periodic operators, providing insight into quantum ergodicity. In this talk we will present results on preserving irreducibility of the Bloch variety after changing the period lattice. This is joint work with Jordy Lopez.

Authors: Matthew Faust (Texas A&M University), Jordy Lopez Garcia (Texas A&M University)

MS18: Algebraic Combinatorics and Parking Functions

Organizers: Nathan Williams (University of Texas at Dallas)
Time: Saturday (11/4) 01:30 pm - 03:30 pm, Saturday (11/4) 03:45 pm - 04:45 pm, Sunday (11/5) 09:45 am - 10:45 am
Venue: Griffin 202

B3.1 Time: Saturday (11/4) 01:30 pm - 02:00 pm

Title: Triangular Partitions

Presenter: Mikhail Mazin

Affiliation: Kansas State University

Abstract: Triangular partitions are partitions whose Ferrers diagrams consist of all boxes that fit under an arbitrary fixed straight line. This class of partitions generalizes the staircase partitions and maximal rational Dyck paths. Recently, triangular partitions picked interest of combinatorialists due to generalizations of the Shuffle Theorem. In this talk I will describe some interesting properties of the triangular partitions. In particular, I will show that they form a lattice under inclusion, and provide a characterization of the triangular partitions in terms of the horizontal steps. This talk is based on a joint work with François Bergeron.

Authors: Mikhail Mazin (Kansas State University) and François Bergeron (Université du Québec à Montréal)

B3.2 Time: Saturday (11/4) 02:00 pm - 02:30 pm

Title: Descents polynomial and parking functions

Presenter: Erik Carlsson

Affiliation: University of California, Davis

Abstract: I'll explain some explicit monomial bases for various spaces which generalize the coinvariant Algebras, and how they appear in the context of Springer fibers. This includes joint work with A. Oblomkov and R. Chou.

Authors: Erik Carlsson (University of California, Davis), Alexei Oblomkov (University of Massachusetts Amherst), Raymond Chou (University of California, San Diego)

B3.3 Time: Saturday (11/4) 02:30 pm - 03:00 pm

Title: Intersection Posets and Weyl Cones of Shi Arrangements

Presenter: Galen Dorpalen-Barry

Affiliation: University of Oregon

Abstract: A celebrated result of Pak-Stanley relates parking functions of a fixed length to the chambers of a real hyperplane arrangement: the (Type A) Shi arrangement. The Braid Arrangement naturally subdivides the set of Shi chambers into n! Weyl cones, thus refining the set of parking functions. In other types, the regions of the Shi arrangement can be labled with antichains of the root poset, and Armstrong–Rhoades–Reiner characterized which antichains appear as chambers in each of these Weyl cones. In this talk, we consider intersection posets corresponding to Weyl cones, and provide bijections between regions, flats intersecting the cone, and antichains of a naturally-defined subposet of the root poset. This gives a refinement of the parking function numbers via the Poincaré polynomials of the intersection posets of all Weyl cones.

Authors: Galen Dorpalen-Barry (University of Oregon) and Christian Stump (Ruhr-Universität Bochum)

B3.4 Time: Saturday (11/4) 03:00 pm - 03:30 pm

Title: Decompositions of parking spaces and reflection Laplacians

Presenter: Theo Douvropoulos

Affiliation: Brandeis University

Abstract: In the early 90's Haiman introduced the module of diagonal harmonics for a natural S_n-action. It has now become a central object in algebraic combinatorics, representation theory, and algebraic geometry, and after work of Gordon, Cherednik, Oblomkov and many more, it has a sibling for (at least) all real reflection groups W: the so called parking space Park(W). In the type-A setting, the space Park(S_n) can be decomposed into a sum of coset representations whose coefficients count combinatorial objects, such as Dyck paths; this is only part of a rich theory encoded for instance in the shuffle theorem. Trying to generalize this, the Coxeter-Combinatorics community has constructed two (ungraded) models for Park(W): the finite torus orbits, known as the W-nonnesting partitions, and the elements below a fixed Coxeter element in reflection order, known as the W-non-crossing partitions. The latter ones are defined for all real, in fact all well-generated complex reflection groups and it has been a long open problem to give a case-free proof of this decomposition

of Park(W). I will present recent work, in part joint with Matthieu Josuat-Vergès, where we give the first such proof; our approach proceeds via comparing natural recursions on the combinatorial objects with their representation-theoretic counterparts. The main technical ingredient is a spectral study of the W-Laplacian operator, which allows us to prove complicated relations involving the Coxeter numbers of W and its parabolic subgroups. Remarkably our calculations suggest also that certain multiplicities on restricted reflection arrangements are free and that they agree with generalizations of the Euler multiplicities of Abe-Terao-Wakefield. Given enough time, I will also present these conjectures and discuss connections with possible graded versions of the parking space decompositions.

Authors: Theo Douvropoulos (Brandeis University) and Matthieu Josuat-Vergès (IRIF, CNRS, & Université Paris Cité)

B4.1 Time: Saturday (11/4) 03:45 pm - 04:15 pm

Title: 2-Dimensional Vector Parking Functions

Presenter: Catherine H. Yan

Affiliation: Texas A&M University

Abstract: Two generalizations of classical parking functions are graphical parking functions and vector parking functions. Graphical parking functions, or G -parking functions, are functions defined on the vertices of a connected multigraph G with specific conditions, while vector parking functions are sequences of non-negative integers whose order statistics are bounded by a given integer sequence $\mathbf{u} = (u_0, u_1, u_2, \dots)$. Motivated by the theory of multivariate Gončarov polynomials, we propose a notion of 2-dimensional parking function, and discuss its relations with vector parking functions and graphical parking functions.

Authors: Ayo Adeniran (Colby College), Lauren Snider (Texas A&M University), and Catherine Yan (Texas A&M University)

B4.2 Time: Saturday (11/4) 04:15 pm - 04:45 pm

Title: Periodic Points of Parking Functions

Presenter: Garrett Nelson

Affiliation: Kansas State University

Abstract: I'll explore an action defined by Jon McCammond, Hugh Tomas, and Nathan Williams. Words in $[m]$ act on points in $V^m = \{\mathbf{x} = (x_0, x_1, \dots, x_{m-1}) \in \mathbb{R}^m : \sum_i x_i = 0\}$. I'll prove that if $\mathbf{p}$ is an $(m, n)-$parking function with m and n coprime then the sequence $\{\mathbf{p}^k\mathbf{x}\}_{k\in\mathbb{Z}_{\geq 0}}$ converges to the alcove that contains the unique fixed point of $\mathbf{p}$. This proof will classify which $\mathbf{x} \in V^m$ converge to the unique fixed point of $\mathbf{p}$ and which become periodic after some $k \in \mathbb{Z}_{\geq 0}$. When m and n are not coprime I'll also investigate how the set of fixed points of a parking function relate to equivalence classes of (m, n)-invariant sets.

Authors: Garrett Nelson (Kansas State University)

B4.3 Time: Sunday (11/5) 09:45 am - 10:15 am

Title: Trees from Affine Braid Varieties

Presenter: Nathan Williams

Affiliation: University of Texas at Dallas

Abstract: Motivated by certain braid varieties over loop groups, we give a bijection between the classical set of vertex-labeled trees on n vertices and a new set of cyclic factorizations of a certain translation element in the affine symmetric group.

Authors: Esther Banaian (Aarhus University), Anh Trong Nam Hoang (University of Minnesota), Elizabeth Kelley (University of Illinois Urbana-Champaign), and Nathan Williams (University of Texas at Dallas)

B4.4 Time: Sunday (11/5) 10:15 am - 10:45 am

Title: Rational Catalan Numbers for Complex Reflection Groups

Presenter: Weston Miller

Affiliation: University of Texas at Dallas

Abstract: The spetsial complex reflection groups are well-generated complex reflection groups that behave as if they were the Weyl group for some connected reductive algebraic group. Analogs of unipotent characters, Harish-Chandra theory, and Lusztig's Fourier transform can be defined combinatorially for these groups, allowing some techniques from the representation theory of finite groups of Lie type to be extended to spetsial complex reflection groups. In a recent paper, Galashin, Lam, Trinh, and Williams introduced a family of rational noncrossing objects for finite Coxeter groups using distinguished subwords. They then gave a type-uniform proof that these objects are counted by rational Coxeter-Catalan numbers by using Hecke algebra traces to compute the point count of braid Richardson varieties. Assuming standard conjectures, I prove that this trace technique extends to irreducible spetsial complex reflection groups. In particular, even though there are not braid Richardson varieties in this context, the trace of a power of a Coxeter element still produces a rational Catalan number. I'll also discuss applications to parking combinatorics.

Authors: Weston Miller (University of Texas at Dallas)

MS19: Across scale modeling in population dynamics & validating with data

Organizers: Hayriye Gulbudak (UL Lafayette) and Nazia Afrin (UL Lafayette)
Time: Sunday (11/5) 11:00 am - 01:00 pm
Venue: Oliver 117

B5.1 Time: Sunday (11/5) 11:00 am - 11:30 am

Title: Dynamics of polyaneuploid cancer cell quiescence under stress

Presenter: Hana Dobrovolny

Affiliation: Texas Christian University

Abstract: Pancreatic metastatic cancer prompts the aggressive emergence of a subsect of cancer cells known as Polyaneuploid Cancer Cells (PACCs) that can become quiescent when confronted with stressors. The quiescent state renders these cells immune to treatments. Mathematical models of cancer treatment have not yet investigated the effect of PACC quiescence on the effectiveness of treatment. In this study, we examine three mathematical models of increasing complexity describing the role of PACCs in tumor growth and treatment. We find that in the absence of treatment, normal cancer cells and PACCs reach equilibrium values that depend on the rate of PACCs formation. During treatment, the presence of PACCs makes it more difficult to eliminate the tumor since the stress of treatment causes cells to move to the quiescent state. This work helps elucidate the role of PACCs in pancreatic cancer.

Authors: Caitlin Garrett and Hana Dobrovolny, Department of Physics and Astronomy, Texas Christian University

B5.2 Time: Sunday (11/5) 11:30 am - 12:00 pm

Title: Characterizing a novel dengue vaccine by leveraging clinical trial data with a multi-level model

Presenter: Manar Alkuzweny

Affiliation: University of Notre Dame, Department of Biological Sciences

Abstract: A safe and effective vaccine that can be universally administered could be key to effectively controlling dengue. Takeda's QDENGA, which recently completed phase-III clinical trials, is a potential candidate for such a vaccine. However, initial trial results suggest that QDENGA may have differential protection by outcome, infecting serotype, and baseline serostatus. To accurately account for this differential protection when projecting impact of QDENGA, it is necessary to obtain estimates of protection that accord with how impact projection models are parameterized. We did so by developing a multi-level model using a survival analysis framework that simultaneously considers trial-wide, country-level, age-specific, and serostatus-specific clinical trial data on reported cases and hospitalizations in both treatment and placebo arms to estimate vaccine and epidemiological parameters. We found that protection varied by both serotype and serostatus, with protection against disease ranging from 70.9% (95% CI: 62.0, 80.6) among seropositives infected by DENV-2 to -17.4% (95% CI: -87.4, 42.2) among seronegatives infected by DENV-4. Importantly, using a multi-level model to account for shared baseline epidemiological characteristics between arms allowed us to obtain efficacy estimates with reduced uncertainty relative to trial estimates. This is highlighted by our estimates for protection against hospitalization due to DENV-3 among seronegatives. While the trial estimated an efficacy of -87.9% (95% CI: -573.4, 47.6), indicating enhanced risk of disease, our model estimates a value closer to the null (-21.7%, 95% CI: -79.6, 33.1). These results suggest that while QDENGA may be an important tool in controlling dengue, the heterogenous protection it offers may hamper its impact.

Authors: Manar Alkuzweny (University of Notre Dame, Department of Biological Sciences and Eck Institute for Global Health), Guido España (University of Notre Dame, Department of Biological Sciences and Eck Institute for Global Health), and Alex Perkins (University of Notre Dame, Department of Biological Sciences and Eck Institute for Global Health)

B5.3 Time: Sunday (11/5) 12:00 pm - 12:30 pm

Title: A mathematical model of tuberculosis and diabetes co-infection dynamics with saturated treatment

Presenter: Saburi Rasheed

Affiliation: University of Louisiana at Lafayette

Abstract: Tuberculosis (TB) is a communicable disease that affects the lungs and is caused by the bacterium Mycobacterium tuberculosis. Latent Tuberculosis Infections (LTBIs) is a condition when the pathogen that causes TB lives in the body without making the person sick. TB is a chronic health concern, especially for people living with diabetes. One of the End TB strategies adopted by the United Nations is to treat LTBIs in the population and also among those living with other noncommunicable diseases including diabetes mellitus (DM). The double trouble also poses a huge financial burden on patients living with the co-morbidities of TB and DM. In this preliminary study, we develop and analyze a deterministic mathematical model of TB and DM co-infection incorporating the saturated treatment of latent tuberculosis infections in the diabetic and non-diabetic populations.

Authors: Saburi Rasheed (University of Louisiana at Lafayette)

B5.4 Time: Sunday (11/5) 12:30 pm - 01:00 pm

Title: Understanding Neutrophil Dynamics during Covid-19 Infection

Presenter: Quiyana M. Murphy

Affiliation: Virginia Tech Department of Mathematics

Abstract: Infection with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) results in varied clinical outcomes, with virus-induced chronic inflammation and tissue injury being associated with enhanced disease pathogenesis. To determine the role of tissue damage on immune populations recruitment and function, a mathematical model of innate immunity following SARS-CoV-2 infection has been proposed. The model was fitted to published longitudinal immune marker data from patients with mild and severe COVID-19 disease and key parameters were estimated for each clinical outcome. Analytical, bifurcation, and numerical investigations were conducted to determine the effect of parameters and initial conditions on long-term dynamics. The results were used to suggest changes needed to achieve immune resolution.

Authors: Quiyana M. Murphy(Virginia Tech Department of Mathematics) and Stanca M. Ciupe (Virginia Tech Department of Mathematics)

MS20: Advances in computational techniques for numerical solutions of partial differential equations

Organizers: Lisa Kuhn (Southeastern Louisiana University)
Time: Sunday (11/5) 11:00 am - 01:00 pm
Venue: Griffin 130

B5.1 Time: Sunday (11/5) 11:00 am - 11:30 am

Title: Numerical studies of finite element solutions to one and two-dimensional structures

Presenter: Lisa M. Kuhn

Affiliation: Southeastern Louisiana University

Abstract: Recent advances in the development of smart materials have impacted the intricacy of partial differential equation structures. These equations often have material discontinuities and complicated boundary conditions, particularly when considering systems of differential equations. Recent finite element solutions are presented for one and two dimensional linear clamped structures. Computational techniques, including the implementation of external ordinary differential equation solvers, modified higher-order bases, and machine-learned elements are discussed.

Authors: Lisa M. Kuhn (Southeastern Louisiana University)

B5.2 Time: Sunday (11/5) 11:30 am - 12:00 pm

Title: Challenges with simulating multiple component beam structures with linear control design

Presenter: Justin Biggs

Affiliation: Louisiana Tech University

Abstract: This work is focused on the analysis of two cantilevered beam systems representing a single wing and a beam-mass-beam system representing a micro aerial vehicle. The single wing is modeled using an Euler-Bernoulli beam with the left end subject to clamped conditions. The aircraft is simulated using two Euler-Bernoulli beams connected to a rigid mass with a clamped left end condition. Linear control design is applied to each system. A finite element method with a choice of cubic b-spline basis vectors is used to solve these systems. Some MATLAB features such as ODE solvers and Ricatti equation solvers present some computational challenges.

Authors: Justin Biggs (Louisiana Tech University)

B5.3 Time: Sunday (11/5) 12:00 pm - 12:30 pm

Title: Neural network method for solving parabolic two-temperature micro/nanoscale heat conduction in double-layered thin films exposed to ultrashort-pulsed lasers

Presenter: Jacob Boyt

Affiliation: Louisiana Tech University

Abstract: Ultrashort-pulsed lasers have been widely applied in biology, chemistry, medicine, physics, and optical technology due to their high efficiency, high power density, minimal collateral material damage, lower ablation thresholds, high precision production ability, and high precision control of heating times and locations in thermal processing of materials. Simulation of the micro/nanoscale heat conduction induced by ultrashort-pulsed laser heating has been attracting great attention. Parabolic two-temperature energy transport model is one of successful mathematical models for predicting phonon (lattice) temperature and electron temperature in metal at the micro/nanscale where energy is induced by ultrashort-pulsed laser heating. As we are moving towards the era of artificial intelligence, machine and deep learning techniques are becoming an important tool in engineering and science research. In this talk, I will present some recently obtained research results in my group. We have obtained an artificial neural network (ANN) method for solving the parabolic two-temperature heat conduction equations in double-layered thin films exposed to ultrashort-pulsed lasers. The ANN method is developed based on the PINN method, particularly the combination of the Adam optimization method and the L-BFGS iterative method for optimizing weights and biases. Convergence of the ANN solution to the analytical solution is theoretically analyzed. Finally, the ANN method is used to predict the electron and lattice temperatures in a gold film padding on a chromium film when exposed to ultrashort-pulsed lasers, which is based on the parabolic two temperature heat conduction model.

Authors: Weizhong Dai (Louisiana Tech University)

B5.4 Time: Sunday (11/5) 12:30 pm - 01:00 pm

Break/Discussion

MS21: Modern Methods for Solution of Inverse Problems

Organizers: Sue Minkoff (Department of Mathematical Sciences, University of Texas at Dallas)
Time: Saturday (11/4) 09:45 am - 11:45 am
Venue: Oliver 116

B2.1 Time: Saturday (11/4) 09:45 am - 10:15 am

Title: A comparison of extension methods for seismic inversion

Presenter: Susan E. Minkoff

Affiliation: University of Texas at Dallas

Abstract: Estimating subsurface parameters non-invasively is useful for a variety of applications including hydrocarbon exploration, carbon sequestration, geothermal energy, etc. In the seismic inverse problem a disturbance causes a wave to be generated which propagates from the source of energy to a recording device (for example, a seismometer or geophone). One then works backwards to minimize the misfit between data recorded at these receivers and data one predicts from a model of the wave equation with estimated input parameters such as wave velocity. This full-waveform inversion (FWI) problem is well known to have lots of local minimizers which fit the data equally well but are not geologically informative. In the last two decades extension methods which relax physical constraints to allow for a wider class of solutions have become popular as they have been shown to reduce the number of stationary points of the objective function. While several such methods exist, their relationship is not well understood. In this talk we will examine connections between some of these extension ideas.

Authors: Susan E. Minkoff (University of Texas at Dallas), Huiyi Chen (University of Texas at Dallas) and Bill Symes (Rice University)

B2.2 Time: Saturday (11/4) 10:15 am - 10:45 am

Title: Waveform inversion via reduced order modeling

Presenter: Alexander Mamonov

Affiliation: University of Houston

Abstract: We present a novel approach to full waveform inversion (FWI), based on a data driven reduced order model (ROM) of the wave equation operator. The unknown medium is probed with pulses and the time domain pressure waveform data is recorded on an active array of sensors. The ROM is a projection of the wave equation operator on a subspace of wave equation solution snapshots. It can be computed from the measured data via a nonlinear process and subsequently used for efficient velocity estimation. While the conventional FWI via nonlinear least-squares data fitting is challenging without low frequency information, and prone to getting stuck in local minima (cycle skipping effect), minimization of ROM misfit is behaved much better, even for a poor initial guess. For low-dimensional parametrizations of the unknown velocity the ROM misfit function is demonstrably close to convex. The proposed approach consistently outperforms conventional FWI in standard synthetic tests, as demonstrated in the numerical experiments.

Authors: Liliana Borcea (University of Michigan), Josselin Garnier (Ecole Polytechnique), Jorn Zimmerling (Uppsala University)

B2.3 Time: Saturday (11/4) 10:45 am - 11:15 am

Title: Optimal Transport for Elastic Source Inversion

Presenter: Tyler Masthay

Affiliation: University of Texas at Austin

Abstract: Full-waveform inversion (FWI) is a state-of-the-art method for imaging the earth's subsurface. However, FWI is notorious for local-minimum trapping, or "cycle skipping," and thus requires an accurate initial model. Cycle skipping is caused by the nonconvex nature of the misfit optimization landscape in its typical least-squares formulation. The Wasserstein-2 distance is convex with respect to shifts and dilations, both of which occur naturally in seismic data. Therefore, we propose using this optimal transport metric as our misfit for FWI. Previous work using optimal transport for source inversion, whose applications include microseismic event detection and deformation mechanics in subduction zones, has shown promise. However, this work uses the acoustic wave equation, which is less accurate than the elastic wave equation. In this paper, we extend these results to elastic source inversion in two spatial dimensions and show that they translate well to the elastic model.

Authors: Tyler Masthay (University of Texas at Austin) and Bjorn Engquist (University of Texas at Austin)

B2.4 Time: Saturday (11/4) 11:15 am - 11:45 am

Break/Discussion

MS22: Coding theory and Cryptography

Organizers: Henry Chimal-Dzul (University of Notre Dame) and Alperen Ergur (University of Texas at San Antonio) and Jingbo Liu (Texas A&M University - San Antonio)
Time: Saturday (11/4) 09:45 am - 11:45 am, Saturday (11/4) 01:30 pm - 03:30 pm, Saturday (11/4) 03:45 pm - 04:45 pm, Sunday (11/5) 09:45 am - 10:45 am, Sunday (11/5) 11:00 am - 01:00 pm
Venue: Griffin 215

B2.1 Time: Saturday (11/4) 09:45 am - 10:15 am

Title: On a Class of Optimal Locally Recoverable Codes with Availability

Presenter: Giacomo Micheli

Affiliation: University of South Florida

Abstract: An $[n, k, d, r]$ Locally Recoverable Code (LRC) is a linear code of dimension k, length n, minimum distance d, and locality r, where the locality is the minimum number of coordinates of a codeword one has to access when recovering a single erasure. In this paper we construct a new family of optimal locally recoverable codes with availability t, i.e. any node has t distinct recovery sets. Our codes, for some sets of parameters, achieve the generalized Singleton bound for Locally Recoverable Codes, while still allowing availability of nodes. From an information theoretical perspective, this is possible because the inequalities for the distance that take into account availability simply return the Singleton bound in certain regimes of parameters n, k, r, d, t, even with $t \geq 2$. This allows the existence of codes with availability $t > 1$ that still match the Singleton bound for LRCs mentioned earlier. Our construction relies on a new combinatorial structure, arising from the theory of finite fields, that allows to produce orthogonal partitions by leveraging the arithmetic of polynomial rings.

Authors: Giacomo Micheli (University of South Florida)

B2.2 Time: Saturday (11/4) 10:15 am - 10:45 am

Title: Generic Error SDP and Generic Error CVE

Presenter: Felice Manganiello

Affiliation: Clemson University

Abstract: In this talk we generalize the concept of error sets beyond those defined by a metric and use the set-theoretic difference operator to characterize when these error sets are detectable or correctable by codes. We prove the existence of a general, metric-less form of the Gilbert-Varshamov bound, and show that - like in the Hamming setting - a random code corrects a generic error set with overwhelming probability. We define the generic error SDP (GE-SDP), which is contained in the complexity class of NP-hard problems, and use its hardness to demonstrate the security of generic error CVE (GE-CVE).

Authors: Felice Manganiello (Clemson University) and Freeman Slaughter (Clemson University)

B2.3 Time: Saturday (11/4) 10:45 am - 11:15 am

Title: Transforming Adversarial MACs to Erasure Channels for Partial Correction

Presenter: Allison Beemer

Affiliation: University of Wisconsin-Eau Claire

Abstract: Adversarial multiple-access channels (MACs) model scenarios in which multiple users transmit to a single receiver in the presence of a malicious adversary. Previous work demonstrated that in the two-user case, given a set of channel conditions, it may be possible to correct one of the users' messages even if the remaining message is too corrupted to decode. A proof of concept was given that uses a short block length partial correction code to transform the adversarial MAC into a set of erasure channels instead. In this talk, we extend these results to a larger number of users and discuss the applicability to a general adversarial MAC.

Authors: Allison Beemer (University of Wisconsin-Eau Claire) and Maddy St.Pierre (University of Wisconsin-Eau Claire)

B2.4 Time: Saturday (11/4) 11:15 am - 11:45 am

Title: Graphical Characterization of Decoding Failures for Quantum LDPC Codes

Presenter: Kirsten Morris

Affiliation: University of Nebraska-Lincoln

Abstract: Key to understanding the performance of quantum low density parity check (QLDPC) codes is to understand their decoding failures. Using the Tanner Graph representation of QLDPC codes we study the subsets of variable nodes that, when in error, cause a decoding failure under certain graph-based iterative decoders. In this talk we extend results in the classical LDPC setting on the impact of a specific class of variable nodes, known as absorbing sets, to the QLDPC context.

Authors: Kirsten Morris (University of Nebraska-Lincoln), Tefjol Pllaha (University of Nebraska-Lincoln), Christine Kelley (University of Nebraska-Lincoln)

B3.1 Time: Saturday (11/4) 01:30 pm - 02:00 pm

Break/Discussion

B3.2 Time: Saturday (11/4) 02:00 pm - 02:30 pm

Break/Discussion

B3.3 Time: Saturday (11/4) 02:30 pm - 03:00 pm

Title: Monomial norm-trace codes

Presenter: Hiram H. López

Affiliation: Virginia Tech

Abstract: We define high-rate norm-trace codes, which depend on the evaluation of certain polynomials on the affine points of the norm-trace curve. We see how the Gröbner basis of the vanishing ideal of the affine points and their indicator functions help us to find the dual of the code. We show that the trace function helps recover an erased entry of a codeword using partial information from the rest of the entries. This recovery property has applications for distributed storage systems. This research is joint work with Cicero Carvalho and Gretchen Matthews.

Authors: Hiram H. López (Virginia Tech), Cicero Carvalho (Universidade Federal de Uberlândia), and Gretchen Matthews (Virginia Tech)

B3.4 Time: Saturday (11/4) 03:00 pm - 03:30 pm

Title: Subfield subcodes of projective Reed-Solomon codes

Presenter: Rodrigo San-José

Affiliation: Universidad de Valladolid

Abstract: Considering subfield subcodes of linear codes is a standard technique for constructing long linear codes over a small finite field. For instance, BCH codes can be obtained in this way from Reed-Solomon codes. The main problem when considering subfield subcodes is computing the dimension and obtaining a basis for the subfield subcode. In this talk we focus on projective Reed-Solomon codes. By studying their subfield subcodes and their duals, we are able to construct both symmetric and asymmetric entanglement-assisted quantum error-correcting codes, which in many cases have new or better parameters than the ones available in the literature. Moreover, with this approach from evaluation codes, we can also evaluate in different sets of points, for instance the roots of a trace function. In this way we are able to obtain classical linear codes with record parameters according to codetables.de, and new quantum codes.

Authors: Philippe Gimenez (Universidad de Valladolid), Diego Ruano (Universidad de Valladolid) and Rodrigo San-José (Universidad de Valladolid)

B4.1 Time: Saturday (11/4) 03:45 pm - 04:15 pm

Title: List Decoding of Skew Reed-Solomon Codes

Presenter: Daniel P. Bossaller

Affiliation: University of Alabama in Huntsville

Abstract: In the presence of errors which exceed the unique decoding bound $t \leq \lfloor \frac{d-1}{2} \rfloor$, it may be desirable to instead output a short list of codewords nearby a given received vector rather than the nearest codeword, such a practice is called "list decoding." List decoding algorithms for Reed-Solomon codes were first introduced by Sudan in 1997 and further expanded by Guruswami and Sudan in 1999. Since then, list decoding algorithms have been investigated for other evaluation codes. This talk will focus on work by Herden and myself which examines the list decoding problem for skew Reed-Solomon codes. This is a preliminary report on joint work with Daniel Herden (Baylor University).

Authors: Daniel P. Bossaller (University of Alabama in Huntsville) and Daniel Herden (Baylor University)

B4.2 Time: Saturday (11/4) 04:15 pm - 04:45 pm

Title: Nonlinear Reed Solomon codes

Presenter: Indalecio Ruiz Bolanos

Affiliation: Baylor University

Abstract: In error-correction codes, we are interested in designing strategies to detect and correct errors that arise from communication and storage problems. The ring of skew polynomials is a non-commutative collection of polynomials with very different properties when compared with the usual ring of polynomials. This structure has motivated more than one strategy to solve the error correction problem. In this work, we analyze a variety of $\mathbb{F}_q$-linear evaluation codes over $\mathbb{F}_{q^m}$, where the evaluation is realized in the classical sense. These codes exhibit properties similar to those found in the skew cyclic and skew quasi-cyclic codes introduced by Boucher & Ulmer and Abualrub et. al, respectively.

Authors: Indalecio Ruiz Bolanos, Daniel Herden (Baylor University) and Daniel Bossaller (University of Alabama in Huntsville)

B4.3 Time: Sunday (11/5) 09:45 am - 10:15 am

Title: Total Break of a Public Key Cryptosystem Based on a Group of Permutation Polynomials

Presenter: Ryann Cartor

Affiliation: Clemson University

Abstract: Singh, Sarma, and Saikia introduced the Permutation Polynomial Encryption Scheme in 2020. We simplify the private key and prove the scheme can be completely broken by a direct algebraic attack. Furthermore, we show that the direct attack also completely breaks the IC cryptosystem. Although other attacks on this scheme were known, it was previously incorrectly asserted that Gröbner basis method is not feasible against IC. We also highlight that this attack is effective against any generalization of these schemes that contain specific properties necessary for inversion.

Authors: Max Cartor (University of Louisville), Ryann Cartor (Clemson University), Mark Lewis (University of Louisville) and Daniel Smith-Tone (University of Louisville, NIST)

B4.4 Time: Sunday (11/5) 10:15 am - 10:45 am

Title: Concrete hardness in lattice-based cryptography

Presenter: Shi Bai

Affiliation: Florida Atlantic University

Abstract: Lattice-based cryptography holds a great promise for post-quantum cryptography. The learning with errors (LWE) problem (Regev, STOC'05) is one of the fundamental problems in lattice-based cryptography. It has been used extensively as a security foundation, for public-key encryption, signatures and many others. In this talk, we will discuss various algorithms for solving the LWE, focusing on the concrete security of the schemes. We will also discuss some recent developments in lattice reduction algorithms in the classic and quantum setting.

Authors: Shi Bai (Florida Atlantinc University)

B5.1 Time: Sunday (11/5) 11:00 am - 11:30 am

Title: A physical study of the LLL algorithm

Presenter: Seungki Kim

Affiliation: University of Cincinnati

Abstract: We present ample evidence suggesting that the dynamics and the output profile of the LLL algorithm is very much like that of sandpile models from statistical physics. This observation sheds light on many of the folklore mysteries concerning the most fundamental lattice reduction algorithm.

Authors: Jintai Ding (Tsinghua U.), Seungki Kim (U. Cincinnati), Tsuyoshi Takagi (U. Tokyo), Yuntao Wang (Osaka U.), Bo-Yin Yang (Academia Sinica)

B5.2 Time: Sunday (11/5) 11:30 am - 12:00 pm

Title: On the Performance Evaluation of Wiretap Codes

Presenter: Aria Nosratinia

Affiliation: University of Texas at Dallas

Abstract: The design of physical layer secrecy codes for the wiretap channel has seen a surge of interest. The practical design and evaluation of physical layer secrecy codes, including wiretap channel codes, requires the calculation of information leakage. Unfortunately, calculating mutual information across a channel subject to a known (specific) codebook has been deemed infeasible. Therefore, the bit-error rate of the eavesdropper has been used as an ersatz metric for information leakage. This talk will begin by highlighting the weaknesses of the bit-error rate as a measure of secrecy, including obscuring local weaknesses and insensitivity issues. We will then introduce a new framework for the Monte Carlo simulation of information leakage while transmitting via a codebook that is known to the adversary.

Authors: Aria Nosratinia

B5.3 Time: Sunday (11/5) 12:00 pm - 12:30 pm

Break/Discussion

B5.4 Time: Sunday (11/5) 12:30 pm - 01:00 pm

Break/Discussion

MS23: Mathematical Models for Population and its application to Ecology and Epidemiology

Organizers: Hongying Shu (Shaanxi Normal University) and Guihong Fan (Columbus State University)
Time: Saturday (11/4) 09:45 am - 11:45 am
Venue: Oliver 119A

B2.1 Time: Saturday (11/4) 09:45 am - 10:15 am

Title: Modelling Phytoplankton-Virus Interactions: Phytoplankton Blooms and Lytic Virus Transmission

Presenter: Junping Shi

Affiliation: College of William & Mary

Abstract: A dynamic reaction-diffusion model of four variables is proposed to describe the spread of lytic viruses among phytoplankton in a poorly mixed aquatic environment. The basic ecological reproductive index for phytoplankton invasion and the basic reproduction number for virus transmission are derived to characterize the phytoplankton growth and virus transmission dynamics. The theoretical and numerical results from the model show that the spread of lytic viruses effectively controls phytoplankton blooms. This validates the observations and experimental results of Emiliana huxleyilytic virus interactions. The studies also indicate that lytic virus transmission cannot occur in a low-light or oligotrophic aquatic environment.

Authors: Jimin Zhang (Heilongjiang University), Yawen Yan (Heilongjiang University), and Junping Shi (College of William & Mary)

B2.2 Time: Saturday (11/4) 10:15 am - 10:45 am

Title: Mathematical modeling of population structure in bioreactors seeded with light-controllable microbial stem cells

Presenter: Rongsong Liu

Affiliation: University of Wyoming

Abstract: Industrial bioreactors use microbial organisms as living factories to produce a wide range of commercial products. For most applications, yields eventually become limited by the proliferation of escape mutants that acquire a growth advantage by losing the ability to make products. The goal of this work is to use mathematical models to determine whether this problem could be addressed in continuous flow bioreactors that include a stem cell population that multiplies rapidly and could be used to compete against the emergence of cheater mutants. In this system, external stimuli can be used to induce stem cell multiplication through symmetric cell division, or to limit stem cell multiplication and induce higher production through an asymmetric cell division that produces one stem cell and one new product-producing factory cell. Our results show product yields from bioreactors with microbial stem cells can be increased by 18% to 127% over conventional methods, and sensitivity analysis shows that yields could be improved over a broad range of parameter space.

Authors: Dane Patey (University of Wyoming), Nikolai Mushinikov (University of Wyoming), Grant Bowman (University of Wyoming), Rongsong Liu (University of Wyoming)

B2.3 Time: Saturday (11/4) 10:45 am - 11:15 am

Title: Importance of underlying mechanisms for interpreting relative risk of Clostridioides difficile infection among antibiotic-exposed patients in healthcare facilities

Presenter: Christopher Mitchell

Affiliation: Tarleton State University

Abstract: Clostridioides difficile infection (CDI) is a significant public health threat, associated with antibiotic-induced disruption of the normally protective gastrointestinal microbiota. CDI is thought to occur in two stages: acquisition of asymptomatic colonization from ingesting C. difficile bacteria followed by progression to symptomatic CDI caused by toxins produced during C. difficile overgrowth. The degree to which disruptive antibiotic exposure increases susceptibility at each stage is uncertain, which might contribute to divergent published projections of the impact of hospital antibiotic stewardship interventions on CDI. Here, we model C. difficile transmission and CDI among hospital inpatients, including exposure to high-CDI-risk antibiotics and their effects on each stage of CDI epidemiology. We derive the mathematical relationship between those parameters and observed equilibrium levels of colonization, CDI, and risk ratio of CDI among certain antibiotic-exposed patients relative to patients with no recent antibiotic exposure. We then quantify the sensitivity of projected antibiotic stewardship intervention impacts to alternate assumptions. We find that two key parameters, the antibiotic effects on susceptibility to colonization and to CDI progression, are not identifiable given the data frequently available. Furthermore, the effects of antibiotic stewardship interventions are sensitive to their assumed values. Thus, discrepancies in published projected impacts of antibiotic stewardship interventions may be largely due to model assumptions. Data supporting improved quantification of mechanistic antibiotic effects on CDI epidemiology are needed to better understand stewardship effects.

Authors: Christopher Mitchell (Tarleton State University)

B2.4 Time: Saturday (11/4) 11:15 am - 11:45 am

Title: Neural Network-Based Amortized Bayesian Inference Methods for Parameter Estimation in ODE Epidemic Models

Presenter: Scott Cook

Affiliation: Tarleton State University

Abstract: Classical models of disease outbreaks based rely on systems of ordinary differential equations have been widely successful and are credited with saving millions of lives worldwide. However, ODE models involve parameters that are often poorly understood and difficult to estimate from limited and noisy data. This is especially problematic for Neglected Tropical Diseases (NTD) with unreliable reporting mechanisms. While some parameters can be deduced from biological or social facts, many must be inferred from data. Traditional least-squares point estimates are fragile when applied to low-quality data. This talk introduces a new technique from Bayesian statistics called Amortized Bayesian Inference (ABI) for parameter estimation. Unlike a standard Bayesian posterior, an *amortized* posterior is a neural network trained on many outbreaks simulated by the ODE under different parameter values. The neural network is presented with information observable during an outbreak and trained to infer the underlying parameter values. The trained network is, therefore, *generalizable* to future outbreaks sufficiently similar to training simulations and can generate forecast ensembles of the future course of the outbreak. We present results applying ABI techniques via the BayesFlow Python package to the early phase of the 2020 Covid outbreak. ABI successfully replicates unexpectedly fine details of the outbreak, including weekday-weekend patterns in data collection, reporting lag, and timing of public health interventions. Though highly tuned for Covid, we believe these techniques can be generalized to a much wider set of diseases.

Authors: Scott Cook (Tarleton State University) and Chris Mitchell (Tarleton State University)

MS24: Analysis and Numerical Methods in Mathematical Biology

Organizers: Summer Atkins (Louisiana State University, Department of Mathematics) and Hayriye Gulbudak (University of Louisiana at Lafayette)
Time: Saturday (11/4) 01:30 pm - 03:30 pm
Venue: Oliver 117

B3.1 Time: Saturday (11/4) 01:30 pm - 02:00 pm

Title: Modeling of biological systems using higher-order modified nonstandard finite difference methods for autonomous dynamical systems

Presenter: Hristo V. Kojouharov

Affiliation: University of Texas at Arlington

Abstract: Autonomous dynamical systems are widely used to better understand and accurately predict the dynamic processes occurring in complex biological systems at the molecular, cellular, and organism levels. Nonstandard finite-difference (NSFD) methods have been designed to approximate specific dynamical systems while preserving some of the essential qualitative properties of the biological model for arbitrary discretization step-sizes, thereby avoiding major numerical constraints and improving the computational efficiency. However, existing NSFD methods are generally only of first-order accuracy. In this work, we present new classes of modified NSFD methods, which not only preserve the unconditional positivity of all feasible trajectories and local stability of existing equilibrium points, but also have second-order accuracy. The proposed modified NSFD methods use novel discrete representations of the nonlinear terms in the right-hand side of the systems, as well as modified nonstandard denominator functions in the discretization of the derivative. A set of numerical simulations for select biological systems is also presented to support the theoretical results and highlight the advantages of the new modified NSFD methods over other classical standard and nonstandard numerical methods.

Authors: Fawaz K. Alalhareth (Department of Mathematics, Najran University), Madhu Gupta (Department of Mathematics, SRM University), Hristo V. Kojouharov (Department of Mathematics, The University of Texas at Arlington), and Souvik Roy (Department of Mathematics, The University of Texas at Arlington)

B3.2 Time: Saturday (11/4) 02:00 pm - 02:30 pm

Title: Benchmarking Electrostatic Free Energy of the Nonlinear Poisson-Boltzmann Model for the Kirkwood Sphere

Presenter: Sylvia Amihere

Affiliation: University of Alabama

Abstract: Various numerical packages have been developed to solve the Poisson- Boltzmann equation (PBE) for the electrostatic analysis of solvated biomolecules. A common benchmark test for the PBE solvers is the Kirkwood sphere, for which analytical potential and free energy are available for the linearized PBE. However, the Kirkwood sphere does not admit an analytical solution for the nonlinear PBE involving a hyperbolic sine term. In this talk, we will propose a simple numerical approach, so that the energy of the Kirkwood sphere for the nonlinear PBE can be calculated at a very high precision. Thus, providing a new benchmark test for the future developments of nonlinear PBE solvers. In addition, we will introduce a novel boundary treatment that is valid for both linearized and nonlinear PBE and can be employed in 3D PBE implementations.

Authors: Sylvia Amihere (University of Alabama), Weihua Geng (Southern Methodist University), and Shan Zhao (University of Alabama)

B3.3 Time: Saturday (11/4) 02:30 pm - 03:00 pm

Title: Within-host viral growth and immune response rates predict FMDV transmission dynamics for African Buffalo

Presenter: Joshua Macdonald

Affiliation: School of Zoology, Goerge S. Wise Faculty of Life Sciences, Tel Aviv University

Abstract: Infectious disease dynamics operate across biological scales: pathogens replicate within hosts but transmit among populations. Functional changes in the pathogen-host interaction thus generate cascading effects across organizational scales. We investigated within-host dynamics and among-host transmission of three strains (SAT1, 2, 3) of foot-and-mouth disease viruses (FMDVs) in their wildlife host, African buffalo. We combined data on viral dynamics and host immune responses with mathematical models to ask (i) How do viral and immune dynamics vary among strains?; (ii) Which viral and immune parameters determine viral fitness within hosts?; and (iii) How do within-host dynamics relate to virus transmission? Our data reveal contrasting within-host dynamics among viral strains, with SAT2 eliciting more rapid and effective immune responses than SAT1 and SAT3. Within-host viral fitness was overwhelmingly determined by variation among hosts in immune response activation rates but not by variation among individual hosts in viral growth rate. Our analyses investigating across-scale linkages indicate that viral replication rate in the host correlates with transmission rates among buffalo and that adaptive immune activation rate determines the infectious period. Together, these parameters define the virus's basic reproductive number ($\mathcal{R}_0$), suggesting that viral invasion potential may be predictable from within-host dynamics.

Authors: Joshua Macdonald (TAU), Hayriye Gulbudak (University of Louisiana at Lafayette), Brianna Beechler (Oregon State University), Erin Gorsich (University of Warwick), Simon Gubbins (Pirbright Institute), Eva Perez-Martin (Pirbright Institute), and Anna Jolles (Oregon State University)

B3.4 Time: Saturday (11/4) 03:00 pm - 03:30 pm

Title: Vaccination Acceptance of Rational and Boundedly Rational Parents

Presenter: Tamer Oraby

Affiliation: The University of Texas Rio Grande Valley

Abstract: In this presentation, I will delve into my research focusing on vaccine acceptance among parents who make decisions with varying degrees of rationality. My investigation extends to exploring the impact of social learning and social norms on the choices parents make regarding vaccinating their children against pediatric diseases. Throughout the talk, I will illuminate how the concept of bounded rationality can hinder vaccination campaigns from achieving their intended objectives.

Authors: Tamer Oraby (The University of Texas Rio Grande Valley)

MS25: Data-driven (mathematical and statistical) modeling approaches to population biology

Organizers: Leah LeJeune (Virginia Tech) and Joshua Caleb MacDonald (Tel Aviv University)
Time: Friday (11/3) 03:00 pm - 05:00 pm, Saturday (11/4) 09:45 am - 11:45 am
Venue: Oliver 117

B1.1 Time: Friday (11/3) 03:00 pm - 03:30 pm

Title: Sensitivity Analysis in an Immuno-Epidemiological Vector-Host Model

Presenter: Hayriye Gulbudak

Affiliation: University of Louisiana at Lafayette

Abstract: Sensitivity Analysis (SA) is a useful tool to measure the impact of changes in model parameters on the infection dynamics, particularly to quantify the expected efficacy of disease control strategies. SA has only been applied to epidemic models at the population level, ignoring the effect of within-host virus-with-immune-system interactions on the disease spread. Connecting the scales from individual to population can help inform drug and vaccine development. Thus, the value of understanding the impact of immunological parameters on epidemiological quantities. Here we consider an age-since-infection structured vector-host model, in which epidemiological parameters are formulated as functions of within-host virus and antibody densities, governed by an ODE system.

We then use SA for these immuno-epidemiological models to investigate the impact of immunological parameters on population-level disease dynamics such as basic reproduction number, final size of the epidemic or the infectiousness at different phases of an outbreak. As a case study, we consider Rift Valley Fever Disease utilizing parameter estimations from prior studies. SA indicates that 1% increase in within-host pathogen growth rate can lead up to 8% increase in $\mathcal{R}_\prime$, up to 1% increase in steady-state infected host abundance, and up to 4% increase in infectiousness of hosts when the reproduction number $\mathcal{R}_\prime$ is larger than one. These significant increases in population-scale disease quantities suggest that control strategies that reduce the within-host pathogen growth can be important in reducing disease prevalence.

Authors: Hayriye Gulbudak (UL Lafayette) and Zhuolin Qu (UTSA) Fabio Milner (ASU) and Necibe Tuncer (FAU)

B1.2 Time: Friday (11/3) 03:30 pm - 04:00 pm

Title: Mathematical formulations for representing human risk response in epidemic models

Presenter: Leah LeJeune

Affiliation: Virginia Tech

Abstract: A major component initially missing from COVID-19 mathematical models was an effective method for considering the impact of human behavior on disease transmission, leading to poor predictions for estimating caseloads and deaths. Various models have since emerged which explicitly build human behavior into disease models. We consider these differing modeling methods, exploring the hypothesis that, when modeling human behavior dynamics, choosing a different approach changes mathematical results. Methods range from varying the transmission parameter with respect to time to creating a network model coupling an SIR-type model with a social dynamics network. Models are motivated by a wide range of data types, from data on the influence of social media on human behavior to data on mobility, contact tracing, and infection levels. Of particular interest are models which consider risk response, where humans change their actions (e.g. social distancing) in response to their perception of likelihood of infection (or death due to infection). This mechanism is incorporated into the model so human response to new information ("risk responsiveness") affects disease transmission. Models represent this effect exogenously or endogenously. With the former incorporation, behavioral changes occur independent of the epidemiological mode. This incorporation tends toward over-fitting with data and often fails in projection of disease trajectory. With the latter, behavior shifts are dependent on changes in the epidemiological model. This endogenous incorporation allows for the presence of oscillations in model solutions, representing the outbreak waves observed within the pandemic and results in improved model forecasting abilities.

Authors: Leah LeJeune (Virginia Tech), Lauren Childs (Virginia Tech), Omar Saucedo (Virginia Tech), Navid Ghaffarzadegan (Virginia Tech)

B1.3 Time: Friday (11/3) 04:00 pm - 04:30 pm

Title: Robust parameterization of a viral-immune kinetics model for sequential Dengue virus (DEN-V) infections with Antibody-Dependent Enhancement (ADE)

Presenter: Joshua Macdonald

Affiliation: School of Zoology, George S. Wise Faculty of Life Sciences, Tel Aviv University

Abstract: Dengue (DENV), a globally distributed arboviral pathogen primarily spread by *Aedes* mosquitoes and infecting approximately 390 million individuals annually. A challenge to successful control of DENV is that after primary infection (or vaccination) due to waning, secondarily infected

patients (or vaccinated individuals) can have an elevated risk of severe Dengue due to a phenomenon known as antibody-dependent enhancement (ADE). In this study, we first robustly parameterize a unified within-host viral and immune kinetics model to viral kinetics data for serotypes DENV1, 2, and 3 while allowing independent variation in infection start time. Our model recapitulates the data well, including cross-reactive antibody concentration-dependent enhanced severity in secondary infections, and captures empirically observed differences between primary and secondary infections, such as time to peak viral load, duration of viremia, and maximum viral titer. Subsequently, we (i) show that variation in initial IgG antibody concentration is sufficient to mechanistically explain the observed differences between primary and secondary infection and (ii) leverage our modeling results paired with long-term NS1-specific IgG antibody decay data to estimate the half-life of Dengue IgG antibodies and the time frame of the risk window for escalated disease severity due to ADE.

Authors: Joshua Macdonald (TAU), Hayriye Gulbudak (University of Louisiana at Lafayette)

B1.4 Time: Friday (11/3) 04:30 pm - 05:00 pm

Title: Connecting the evolutionary genetics of HIV to prey-predator dynamics with immune response

Presenter: Cameron Browne

Affiliation: University of Louisiana at Lafayette

Abstract: The dynamic nature of the intra-host HIV evolution during disease progression is still not completely understood. Here, we combine viral genomic and immune population data in the SIV/macaque experimental model of AIDS with mathematical modeling. We investigated the cross-correlation between several immune cell populations and viral genetic diversity measured by coalescent based inference of effective population sizes (Ne). Overall viral Ne was found to oscillate in concertwith changing immune cell population levels. Connecting a virus-immune networkmodel with this data, we observe that simulations mimic the large-scale oscillations in Ne. The model suggests virus escape from relatively few, early immunodominant responses, followed by slower escape from several subdominant and weakened immune populations. To conclude, we outline how we might further explore the observed dynamics by considering recent theoretical results using a combinatorial analysis of the underlying viral sequence fitness landscape and how to link model simulations with phylogenetic tree data.

Authors: Cameron Browne (University of Louisiana at Lafayette) and Brittany Rife Magalis (University of Florida) and Marco Salemi (University of Florida)

B2.1 Time: Saturday (11/4) 09:45 am - 10:15 am

Title: Modeling Immunity to Malaria with an Age-Structured PDE Framework

Presenter: Zhuolin Qu

Affiliation: University of Texas at San Antonio

Abstract: Malaria is one of the deadliest infectious diseases globally, causing hundreds of thousands of deaths each year. It disproportionately affects young children, with two-thirds of fatalities occurring in under-fives. Individuals acquire protection from disease through repeated exposure, and this immunity plays a crucial role in the dynamics of malaria spread. We develop and analyze an age-structured PDE model, which couples vector-host epidemiological dynamics with immunity dynamics. Our model tracks the acquisition and loss of anti-disease immunity during transmission and its corresponding nonlinear feedback onto the transmission parameters. We derive the basic reproduction number (R0) as the threshold condition for the stability of disease-free equilibrium and interpret R0 probabilistically as a weighted sum of cases generated by infected individuals at different infectious stages and ages. Numerical bifurcation analysis demonstrates the existence of an endemic equilibrium, and we observe a forward bifurcation in R0. Our model reproduces the heterogeneity in the age distributions of immunity profiles and infection status created by frequent exposure. Motivated by the recently approved RTS,S vaccine, we also study the impact of vaccination and its implementation in areas with different seasonal variations.

Authors: Zhuolin Qu (University of Texas at San Antonio), Denis Patterson (Durham University), Lauren Childs (Virginia Tech), Christina Edholm (Scripps College), Joan Ponce (Arizona State University), Olivia Prosper (University of Tennessee, Knoxville), and Lihong Zhao (Virginia Tech)

B2.2 Time: Saturday (11/4) 10:15 am - 10:45 am

Title: Bistability in models of Hepatitis B virus dynamics

Presenter: Nazia Afrin

Affiliation: University of Louisiana at Lafayette

Abstract: Despite effective vaccines and improved treatment strategies, hepatitis B virus (HBV) is a major global health concern with 1.5 million newly infected cases each year. It's an infection of the liver caused by the Hepatitis B virus. In this preliminary study, we formulate and analyze a within-host model that describes the progression of acute HBV in liver cells (hepatocytes). We derive the basic reproduction number and investigate the stability of the equilibria via threshold analysis. Analytical and numerical results show that the model exhibits complex bifurcation dynamics such as backward bifurcation. Finally, we discuss the epidemiological implications of bistable dynamics.

Authors: Nazia Afrin, Hayriye Gulbudak (University of Louisiana at Lafayette), Stanca M. Ciupe (Virginia Tech University, Virginia, USA) and Jessica M. Conway (The Pennsylvania State University, Pennsylvania, USA)

B2.3 Time: Saturday (11/4) 10:45 am - 11:15 am

Title: HIV Spread and Treatment Distribution: Two Country Case Studies

Presenter: Joan Ponce

Affiliation: Arizona State University

Abstract: In this talk, we examine two critical aspects of HIV: its spread and equitable access to treatment. First, we investigate the role of population mobility in Botswana's generalized HIV epidemic, where 10% of the population moved annually, connecting mining towns as significant hubs for transmission. This mobility hypothesis suggests how HIV spread throughout the country. Shifting our focus to Malawi, we introduce a spatial interaction model that evaluates spatial accessibility to antiretroviral therapy (ART). Lifelong endemic diseases like HIV require consistent ART access; therefore, disparities in healthcare resources are essential to understand. This model assesses disparities in ART access due to varying demands, supplies, and geographic accessibility to healthcare facilities. By combining insights into HIV transmission dynamics and treatment accessibility, we aim to provide a comprehensive perspective on managing this critical global health challenge.

Authors: Joan Ponce (ASU), Sally Blower (UCLA) and Justin Okano (UCLA)

B2.4 Time: Saturday (11/4) 11:15 am - 11:45 am

Title: An Immuno-epidemiological Model of Foot-and-Mouth Disease in African Buffalo

Presenter: Summer Atkins

Affiliation: Louisiana State University, Department of Mathematics

Abstract: We present a novel immuno-epidemiological model of Foot-and-Mouth Disease (FMD) in African buffalo host population. Upon infection, the hosts can undergo two phases, namely the acute and the carrier stages. In our model, we divide the infectious population based upon these two stages so that we can dynamically capture the immunological characteristics of both phases of the disease and to better understand the carrier's role in transmission. We first define the within-host immune kinetics dependent basic disease reproduction number and show that it is a threshold condition for the local stability of the disease-free equilibrium and existence of endemic equilibrium. By using a sensitivity analysis (SA) approach developed for multi-scale models, we assess the impact of the acute infection and carrier phase immunological parameters on the basic reproduction number. Interestingly, our numerical results show that the within-carrier infected host immune kinetics parameters and the susceptible individual recruitment rates play significant roles in disease persistence, which are consistent with experimental and field studies.

Authors: Summer Atkins(Louisiana State University, Department of Mathematics) and Hayriye Gulbudak (University of Louisiana at Lafayette, Department of Mathematics) and Shane Welker (University of North Alabama, Department of Mathematics) and Houston Smith(Louisiana State University)

MS26: Problems in Kinetic Theory and Nonlinear Waves

Organizers: Thomas Hagstrom (Southern Methodist University)
Time: Friday (11/3) 03:00 pm - 05:00 pm, Saturday (11/4) 01:30 pm - 03:30 pm
Venue: Oliver 116

B1.1 Time: Friday (11/3) 03:00 pm - 03:30 pm

Title: Direct Computation of Singular Solutions for Fluid Models

Presenter: Thomas Hagstrom

Affiliation: Southern Methodist University

Abstract: Many fluid models have, or are believed to have, singularities which develop from smooth data. Challenges to computing such solutions arise from the very fact that they are singular and so violate the assumptions required for guaranteed convergence of the numerical approximations. A successful analytic approach is to reformulate the problem in such a way that smooth solutions of the reformulated equations correspond to singular solutions of the orginal system. Here we demonstrate discretizations of such reformulated problems, obtaining high-order convergence to nonsmooth solutions.

Authors: Thomas Hagstrom (Southern Methodist University)

B1.2 Time: Friday (11/3) 03:30 pm - 04:00 pm

Title: Conformal mappings, computation of dynamics on various Riemann surface sheets and integrability of surface dynamics

Presenter: Pavel Lushnikov

Affiliation: University of New Mexico

Abstract: A fully nonlinear dynamics for potential flow of ideal incompressible fluid with a free surface is considered in two dimensional geometry. Arbitrary large surface waves and motions can be efficiently characterized through a time-dependent conformal mapping of a fluid domain into the lower complex half-plane. The fluid dynamics is fully characterized by the complex singularities in the upper complex half-plane of the conformal map and the complex velocity. Analytical continuation through the branch cuts generically results in the Riemann surface with infinite number of sheets including Stokes wave, An infinite family of solutions with moving poles are found on the Riemann surface. Residues of poles are the constants of motion. These constants commute with each other in the sense of underlying non-canonical Hamiltonian dynamics which provides an argument in support of the conjecture of complete Hamiltonian integrability of surface dynamics. If we consider initial conditions with short branch cuts then fluid dynamics is reduced to the complex Hopf equation for the complex velocity coupled with the complex transport equation for the conformal mapping. These equations are fully integrable by characteristics producing the infinite family of solutions, including the pairs of moving square root branch points. The solutions are compared with the simulations of the full Eulerian dynamics giving excellent agreement. Numerical analytical continuation reveals complex singularity to allow excellent comparison with theory.

Authors: Pavel Lushnikov (University of New Mexico)

B1.3 Time: Friday (11/3) 04:00 pm - 04:30 pm

Title: Uniform Asymptotic Stability for Convection-Reaction-Diffusion Equations in the Inviscid Limit Towards Riemann Shocks

Presenter: Paul Blochas

Affiliation: University of Texas at Austin

Abstract: In this talk, I will present a result obtained in a recent paper about the study of the stability in time of a family of viscous shocks approximating a given Riemann shock, and we aim at showing some uniform asymptotic orbital stability result of these waves in the vanishing viscosity limit. Even at the linear level, to ensure uniformity we decompose the propagator of the linearization into a decreasing part and a phase modulation is carried out in a highly non-standard way. Furthermore, we introduce a multi-scale norm depending in the viscous parameter. To avoid the use of arguments based on parabolic regularization that would preclude a result uniform in the viscous parameter, we close nonlinear estimates on this norm trough some suitable maximum principle.

Authors: Paul Blochas (University of Texas at Austin)

B1.4 Time: Friday (11/3) 04:30 pm - 05:00 pm

Break/Discussion

B3.1 Time: Saturday (11/4) 01:30 pm - 02:00 pm

Title: Cold discrete breathers

Presenter: Benno Rumpf

Affiliation: Southern Methodist University

Abstract: Discrete breathers are spatially localized modes of nonlinear lattices that are relevant in a many physical systems such as crystals and coupled optical fibers. Since the demonstration of their existence for a broad class of weakly coupled nonlinear lattices they have also been an important field of studies for the dynamics and statistical mechanics of nonintegrable Hamiltonian systems. Their persistence in time may appear surprising from the viewpoint of statistical mechanics as localization of energy in a few high-amplitude structures seems to be opposed to what is expected in the thermalization of nonintegrable systems. For systems with a second conserved quantity (e.g. the magnetization in the Landau-Lifshitz equation, the wave action (or modulus-square norm) in

the discrete nonlinear Schrödinger equation), the statistical analysis has shown that the thermal equilibrium state consists of two phases, one of low-amplitude phonons and one of high-amplitude discrete breathers in a certain energy range. This statistical explanation of discrete breathers is not directly applicable to Hamiltonian systems without a second conserved quantity. One statistical approach to explain the formation of breathers in such systems (in particular the discrete nonlinear Klein-Gordon equation) is based on an envelope equation (again of Schrödinger type) that possesses a second "almost conserved" quantity. From this, the formation of breathers can be explained in the same way as for systems with a conserved quantity. At variance to this approach, I will suggest a new statistical explanation of breathers in such systems without invoking a second conserved quantity.

Authors: Benno Rumpf (Southern Methodist University)

B3.2 Time: Saturday (11/4) 02:00 pm - 02:30 pm

Title: Weak solutions of nonlinear, nonconservative transport systems

Presenter: Benjamin Seeger

Affiliation: University of Texas at Austin

Abstract: I will discuss certain systems of transport type whose coefficients depend nonlinearly on the solution. Applications of such systems range from the modeling of pressure-less gases to the study of mean field competitive behavior in a discrete state space. I will identify a notion of weak solution within the class of coordinate-wise decreasing functions, a condition which has particular relevance for applications arising in economics. I demonstrate the existence of a unique maximal and minimal solution, in an appropriate sense, and the discrepancy between the two can be precisely related to the formation of shocks. I will also present a selection principle for the family of solutions based on vanishing (nonlinear) viscosity. The analysis depends on new well-posedness results for linear transport equations with certain rough velocity fields, which are of independent interest.

Authors: Benjamin Seeger (University of Texas at Austin) and P.-L. Lions (Université de Paris-Dauphine-PSL)

B3.3 Time: Saturday (11/4) 02:30 pm - 03:00 pm

Title: Some Recent Results On Wave Turbulence Theory

Presenter: Minh Binh Tran

Affiliation: Texas A&M University

Abstract: Wave turbulence describes the dynamics of both classical and non-classical nonlinear waves out of thermal equilibrium. In this talk, I will present some of our recent results on wave turbulence theory. In the first part of the talk, I will discuss our rigorous derivation of wave turbulence equations. The second part of the talk is devoted to the analysis of wave turbulence equations as well as some numerical illustrations. The last part concerns some physical applications of wave turbulence theory.

Authors: Minh Binh Tran (Texas A&M

B3.4 Time: Saturday (11/4) 03:00 pm - 03:30 pm

Title: Decay Estimates for the non-cutoff Boltzmann equation

Presenter: Andrei Tarfulea

Affiliation: Louisiana State University

Abstract: The Boltzmann equation models a high-energy gas with elastic collisions. From the mathematical point of view, it presents a nonlocal degenerate-parabolic PDE with very few coercive quantities. The existence of global smooth solutions remains an open problem, and the state of the art is summarized by the conditional regularity program: as long as the hydrodynamic quantities (mass, energy, and entropy densities) remain "under control" (satisfying four time-independent inequalities), the solution is in fact smooth. Building on our previous work (establishing local well-posedness for the problem for rough initial data), we prove that polynomial moments in velocity are propagated for as long as the hydrodynamic quantities remain under control; this also improves the continuation criterion. The talk will emphasize a useful (and somewhat novel) analysis of the collision operator which yields pointwise estimates for a maximum principle argument, as a self-contained demonstration of some of the techniques in this area.

Authors: Andrei Tarfulea (Louisiana State University)

MS27: Special Topics in Control and Optimization

Organizers: Zequn Zheng (Louisiana State University, Department of Mathematics) and Summer Atkins (Louisiana State University, Department of Mathematics)
Time: Friday (11/3) 03:00 pm - 05:00 pm
Venue: Griffin 203

B1.1 Time: Friday (11/3) 03:00 pm - 03:30 pm

Title: Approximations of optimal solutions of a Mayer problem for a controlled and time-delayed perturbed sweeping process

Presenter: Vinicio Rios

Affiliation: Louisiana State University

Abstract: This talk revolves around a Mayer-type problem associated with a perturbed Moreau's sweeping process. This category of problems belongs to the challenging paradigm of unbounded discontinuous differential inclusions with built-in state constraints, which remains an underexplored topic, despite its apparent great relevance in control theory applications. In the first part of the talk, we show how to adapt the ideas from (https://doi.org/10.1007/s10107-005-0619-y) to establish an existence result for a Lipschitz perturbation of a sweeping process (PSP) that features both a measurable control function and a time-delayed component. At this stage, we assume the state constraints of the dynamics are represented by an absolutely continuous and r-prox-regular moving set. In the latter part of the talk, we focus on the case of a convex polyhedron moving set. Under this type of state constraint, we present an extension of the scheme designed in (https://doi.org/10.1137/18M1207120) that allows us to approximate the local minimizers of a Mayer problem associated with (PSP) with any sequence of optimal solutions obtained from an auxiliary class of discrete Mayer problems. In future work, we anticipate combining the aforementioned approach with variational analysis tools and a convenient "pass to the limit" procedure to establish necessary conditions for the local minimizers of the Mayer problem under consideration. This is a collaboration with Boris Mordukhovich, Dao Nguyen, Trang Nguyen, and Norma Ortiz-Robinson.

Authors: Boris Mordukhovich (Wayne State University), Dao Nguyen (San Diego State University), Trang Nguyen (Wayne State University), Norma Ortiz-Robinson (Grand Valley State University), and Vinicio Rios (Louisiana State University)

B1.2 Time: Friday (11/3) 03:30 pm - 04:00 pm

Title: Dynamic Event-Triggered Control of Linear Continuous-Time Systems

Presenter: Safeyya Alyahia

Affiliation: Louisiana State University

Abstract: Feedback controls are forcing functions in dynamical systems that can depend on the state of the dynamics and which are chosen such that the dynamics enjoy some prescribed desired qualitative property, such as global asymptotic stability. Event-triggered feedback controls provide a useful alternative to standard continuous-time or sample-data feedback controls. In standard feedback controls, the values taken by the feedback controls change continuously, or at sample times that are independent of the state of the dynamics. By contrast, event-triggered feedback controls only change their values at event triggering times. The trigger times are selected so that the control values only change when the systems being controlled require attention. Event-triggered control is widely used in engineering, especially in resource constrained communication networks where continuously changing control values is not feasible and calls for simultaneously deriving feedback control formulas and deciding on criteria for when to change the control values. This talk presents our recent results on event-triggered feedback control for continuous-time linear systems that contain additive uncertainties. Our controls are dynamic, in the sense that we construct a new dynamical system that determines the feedback control values. Significant novel features include (a) our constructing positive lower bounds on the intervals between consecutive event trigger times to ensure that our method can be implemented, thereby ruling out Zeno's phenomenon, (b) our use of linear Lyapunov functions, interval observers, a positive systems analog of dynamic event-triggered work by A. Girard, and continuous-discrete observers to prove our asymptotic stability properties, (c) our use of vectors of absolute values instead of the Euclidean 2-norm while only requiring sampled state or output values at our event triggering times, instead of continuous measurements of these values, and (d) numerical simulations where our approaches provide the advantage of reducing the numbers of trigger times on given intervals compared with earlier works, when applied to a model of the BlueROV2 underwater vehicle that is commonly used in ecological robotics.

Authors: Safeyya Alyahia (Louisiana State University), Corina Barbalata (Louisiana State University), Michael Malisoff (Louisiana State University), and Frederic Mazenc (INRIA EPI DISCO)

B1.3 Time: Friday (11/3) 04:00 pm - 04:30 pm

Title: A Discrete-Time Trajectory-Based Stabilization Approach

Presenter: Jackson Knox

Affiliation: Louisiana State University

Abstract: Continuous-time trajectory-based estimates play a significant role in mathematical control theory because they can help us prove exponential stability properties in cases that are not necessarily amenable to Lyapunov functions or to other standard control theoretical techniques. These include cases with input delays, where a feedback control for a control system must be computed using time delayed measurements from the system, because current measurements from the system may not be available. Here we present a new class of trajectory-based estimates for discrete-time systems. We use our new estimates to prove an input-to-state stability estimate for a class of discrete-time linear control systems that contain arbitrarily long constant input delays. The control systems use delay-compensating feedback controls that are calculated using a predictor approach, and our input-to-state stability result quantifies the degree of robustness of the delay compensation with respect to uncertainties in coefficient matrices. A key ingredient in our input-to-state stability

proof is our use of interval observers, which provide upper and lower bounds of each component of a solution of the uncertain system. We also provide an application to an observer design that estimates an unmeasured state component of a system.

Authors: Frédéric Mazenc (INRIA EPI DISCO), Michael Malisoff (Louisiana State University), and Jackson Knox (Louisiana State University)

B1.4 Time: Friday (11/3) 04:30 pm - 05:00 pm

Title: Generating Polynomial Method for Non-symmetric Tensor Decomposition

Presenter: Zequn Zheng

Affiliation: Louisiana State University

Abstract: Tensors or multidimensional arrays are higher order generalizations of matrices. They are natural structures for expressing data that have inherent higher order structures. Tensor decompositions play an important role in learning those hidden structures. In this talk, we present a novel algorithm to find the tensor decompositions utilizing generating polynomials. Under some conditions on the tensor's rank, we prove that the exact tensor decomposition can be found by our algorithm. Numerical examples successfully demonstrate the robustness and efficiency of our algorithm.

Authors: Jiawang Nie (University of California at San Diego), Zi Yang (University at Albany SUNY), Hongchao Zhang (Louisiana State University), and Zequn Zheng(Louisiana State University)

MS28: Translational Mathematical Modeling and Data Science in Medicine

Organizers: Charles Puelz (Baylor College of Medicine) and Travis Thompson (Texas Tech University) and Bradley Vigil (Texas Tech University)
Time: Friday (11/3) 03:00 pm - 05:00 pm, Saturday (11/4) 09:45 am - 11:45 am
Venue: Oliver 101

B1.1 Time: Friday (11/3) 03:00 pm - 03:30 pm

Title: The role of clearance in neurodegenerative diseases

Presenter: Travis B. Thompson

Affiliation: Texas Tech University

Abstract: Neurodegenerative diseases are progressive disorders marked by a number of reductions in cognitive faculties before proceeding to a state of dementia. A common characteristic of many neurodegenerative disorders is the formation of protein aggregates throughout the brain; aberrant aggregation is thought to play a causal role in some disorders, such as Alzheimer's disease and amyotrophic lateral sclerosis. The brain harbors a number of clearance mechanisms that reduce aggregation burden throughout life. In this talk, we overview mathematical models of clearance in human brain neurodegeneration. We will see how simplified mathematical models of propagation and clearance emerge from aggregation dynamics and how heterogeneous clearance can alter the trajectory and presentation of neurodegeneration, engendering the further study of specific clearance mechanisms with translational significance.

Authors: Travis Thompson (Texas Tech University) Georgia Brennan (University of Oxford) Hadrien Oliveri (University of Oxford) Marie Rognes (Simula Research Laboratory) Georg Meisl (University of Cambridge) and Alain Goriely (University of Oxford)

B1.2 Time: Friday (11/3) 03:30 pm - 04:00 pm

Title: Computer models and image processing to study surgeries for the treatment of single ventricle physiology

Presenter: Charles Puelz

Affiliation: Baylor College of Medicine

Abstract: Single ventricle physiology refers to a class of heart defects in which there is only one functioning ventricular chamber. This defect is usually treated by a series of surgeries over several years. The are many aspects of these surgeries that can be studied using computer modeling combined with clinical data obtained from imaging sequences. This talk will detail our efforts to study these surgeries using physics-based models with various levels of detail.

Authors: Charles Puelz (Baylor College of Medicine) Dan Lior (Baylor College of Medicine) Justin Weigand (Baylor College of Medicine) Alyssa Taylor-LaPole (North Carolina State University) Mette Olufsen (North Carolina State University)

B1.3 Time: Friday (11/3) 04:00 pm - 04:30 pm

Title: Networks, Topology, Data and Pathology

Presenter: Bradley Vigil

Affiliation: Texas Tech University

Abstract: From epidemics to epilepsy, nature is replete with examples of pathologies that spread atop complex networks. These processes are often described by high-dimensional, coupled systems of differential equations and observations are often limited to sensor processes that inadequately sample the dynamics. The presence of these 'hidden network structures' may alter our perception of spreading behavior. In this talk, we will introduce simple, dynamics-free models of spreading on networks, motivated by applications in medicine. We will discuss how tools from topological data analysis have been applied to study spreading behavior when network structure is known and present evidence that topological methods may also provide a glimpse into the presence of hidden network structure.

Authors: Bradley Vigil (Texas Tech University) Robert Young (Texas Tech University) and Travis Thompson (Texas Tech University)

B1.4 Time: Friday (11/3) 04:30 pm - 05:00 pm

Title: Multigrid Inspired Deep Learning Architectures for Medical Imaging Segmentation

Presenter: Adrian Celaya

Affiliation: Rice University

Abstract: We propose the PocketNet paradigm to reduce the size of deep learning models by throttling the growth of the number of channels in convolutional neural networks (CNNs) and two novel deep learning architectures, FMG-Net and W-Net, to address the limitations in existing CNN architectures to address fine-scale features and variations in image scales. This novel design principle (i.e., PocketNet) and our proposed architectures are based on the principles of geometric multigrid methods (GMMs). With the PocketNet paradigm, we produce results comparable to conventional CNNs while reducing the number of parameters by multiple orders of magnitude, using up to 90 percent less GPU memory, and speeding up training times by up to 40 percent. Our FMG-Net and W-Net architectures showed superior segmentation accuracy compared to the widely used U-Net architecture on the Brain and Tumor Segmentation (BraTS) dataset. Our results with the

PocketNet paradigm and novel architectures indicate that incorporating the principles of GMMs into CNNs for medical imaging segmentation is beneficial in their design, training, and deployment.

Authors: Adrian Celaya (Rice University), Beatrice Riviere (Rice University), and David Fuentes (MD Anderson Cancer Center)

B2.1 Time: Saturday (11/4) 09:45 am - 10:15 am

Title: An immersed peridynamics method for fluid-driven material damage and failure

Presenter: Keon Ho Kim

Affiliation: Oden institute for Computational Engineering and Sciences, University of Texas at Austin

Abstract: Fluid-driven material damage and failure are significant in many engineering and industrial fields, such as tissue failure, fracking, and blasts on structures. However, conventional continuum-based methods have challenges in simulating such fracture mechanics. In this work, we develop an immersed peridynamics method to simulate the deformation, damage, and failure of hyperelastic materials within a fluid-structure interaction framework by integrating immersed-type methods with peridynamics. The convergence and accuracy of the proposed method are compared to conventional finite element and immersed finite element-finite difference methods through well-known solid mechanics benchmark problems for both isotropic and anisotropic materials, and we demonstrate that the proposed method yields comparable accuracy with similar numbers of structural degrees of freedom. We also demonstrate grid-converged fluid-driven material damage growth, crack initiation and formation, and rupture under large deformations.

Authors: Keon Ho Kim (UT Austin) Boyce E. Griffith (UNC Chapel Hill)

B2.2 Time: Saturday (11/4) 10:15 am - 10:45 am

Title: A Pseudo-differential Sweeping Method for the Helmholtz Equation

Presenter: Raven Shane Johnson

Affiliation: Rice University

Abstract: Ultrasound-guided medical procedures often experience complications when imaging heterogeneous tissue. Computer simulations of the ultrasound field offer a workable solution to this heterogeneity problem, but the computational methods required for these simulations tend to be either highly accurate and computationally slow or computationally quick and inaccurate. We propose a sweeping numerical method for solving the Helmholtz equation which is built from a truncated pseudo-differential expansion. The solver is based on explicit time-stepping, and we demonstrate that the proposed sweeping method is not only accurate but increases in accuracy as the angular frequency increases.

Authors: Sebastian Acosta (Baylor College), Jesse Chan (Rice University), Raven Shane Johnson (Rice University)

B2.3 Time: Saturday (11/4) 10:45 am - 11:15 am

Title: Flow and Transport in the Liver Organ

Presenter: Bilyana Tzolova

Affiliation: Rice University

Abstract: This talk focuses on modeling blood flow and solute transport, particularly chemotherapy drugs, within the liver and hepatic tumors. To achieve accurate modeling, we employ a 1D centerline representation of vascular structures derived from CT images, while constructing 3D meshes of the liver and tumors. Using the singularity subtraction technique, we simulate blood flow from a 1D source to a 3D porous medium and extend this approach to model the time-dependent advection-diffusion equation and the coupled flow and transport equations. The research aims to enhance our understanding of blood flow and solute transport, potentially facilitating in the development of more effective treatments for liver cancers.

Authors: Bilyana Tzolova (Rice University), Beatrice Riviere (Rice University) and David Fuentes (University of Texas MD Anderson Cancer Center)

B2.4 Time: Saturday (11/4) 11:15 am - 11:45 am

Title: Hydrodynamic Strategies in Choanoflagellate Colonies: A Reduced Model Approach

Presenter: Hongfei Chen

Affiliation: Tulane University

Abstract: Choanoflagellates, single-cell colonial species, bear molecular similarities to animals, suggesting they are our closest living relatives. Each choanoflagellate has a cell body, a flagellum and a collar of microvilli surrounding the flagellum. By changing their collar angle, colonies of a particular species, the C. Flexa, are capable of inverting between two states: flagella positioned inside and outside the colony. Studying the hydrodynamics of them using detailed models of cells that represent their flagella, microvilli, and cell bodies would be ideal. However, given that there are more than one hundred of cells within a colony, this is not feasible. Reduced models of swimmers are a natural choice. In this research, we introduce a one-point model to represent a single C. Flexa cell. This model captures the averaged far-field flow characteristics derived from a computational choanoflagellate model with full details. Furthermore, we extend our reduced modeling approach to a coarse model for choanoflagellate colonies, both calibrated with experimental data. Leveraging these models, we delve into exploring the hydrodynamic advantages conferred by flagella positioning and elucidate the impact of colony shape and cell arrangements on the collective swimming and feeding performance of choanoflagellate colonies.

Authors: Hongfei Chen (Tulane University), Ricardo Cortez (Tulane University), Hoa Nguyen (Trinity University) , Tom Hata (University of California, Berkeley), Mimi Koehl (University of California, Berkeley), Lisa Fauci (Tulane University)

MS29: Data-driven learning and model reduction

Organizers: Marco Tezzele (The University of Texas at Austin) and Nicole Aretz (The University of Texas at Austin)
Time: Saturday (11/4) 01:30 pm - 03:30 pm
Venue: Griffin 129

B3.1 Time: Saturday (11/4) 01:30 pm - 02:00 pm

Title: Tracking multi-scale river responses to enhanced rock weathering

Presenter: Shuang Zhang

Affiliation: Texas A&M University

Abstract: Enhanced Rock Weathering (ERW) is emerging as a potential solution in the arena of Carbon Dioxide Removal (CDR) strategies, promising not only a sustainable approach to mitigating CO2 levels but also bringing forth potential co-benefits such as enhanced soil pH and nutrient

release. Despite its increasing traction, the comprehensive understanding of ERW's impact on river systems, an essential determinant in evaluating its efficacy, remains deficient, thereby hindering its adoption as a reliable carbon management strategy. This study endeavors to bridge this knowledge gap by leveraging a robust integrated framework that amalgamates data-driven and model-driven approaches, focusing on river systems across North America. Central to our approach is the deployment of a novel Dynamic River Network (DRN) model, developed to facilitate a robust analysis of the riverine responses to ERW application. Our findings reveal a minimal carbon leakage, in the river network remaining below 5% over two years, thereby negating the apprehension of surface waters becoming a bottleneck in realizing ERW's CDR potential. Furthermore, we observe an encouraging stability in the carbonate saturation states across numerous river segments, a testimony to the low propensity of ERW inducing significant disruptions in aquatic systems. The study further delineates pronounced spatial heterogeneities and seasonal variations in the responses, offering a strategic blueprint for optimizing ERW deployment by selecting the most beneficial watersheds and timing.

Authors: Shuang Zhang (Texas A&M University), Christopher Reinhard (Georgia Institute of Technology), Yoshiki Kanzaki (Georgia Institute of Technology), and Noah Planavsky (Yale University)

B3.2 Time: Saturday (11/4) 02:00 pm - 02:30 pm

Title: Efficient geometric MCMC enabled by neural operators with parametric derivative training

Presenter: Lianghao Cao

Affiliation: The University of Texas at Austin

Abstract: This talk presents an operator learning approach to accelerate PDE-constrained Bayesian inversion. This approach involves building a surrogate of the parameter-to-observable map and its parametric derivative via training a derivative-informed neural operator (DINO), first proposed by O'Leary-Roseberry et. al. The learned operator is then used to efficiently generate proposals for function space geometric MCMC. DINO is a model reduction neural operator trained via approximation error minimization in the topology of the H^1 Sobolev space with a Gaussian measure. DINO leads to meaningful evaluations of neural operator derivatives and, thus, rapid sampling from local Gaussian approximations of posterior distributions for Bayesian inversion. We demonstrate that our proposed MCMC procedure based on DINO employs a nonlinear dimension reduction of the parameters space via parametrically rotating the pre-determined reduced basis. Preliminary numerical examples that test the efficiency of the proposed approach are provided.

Authors: Lianghao Cao (The University of Texas at Austin), Thomas O'Leary-Roseberry (The University of Texas at Austin), and Omar Ghattas (The University of Texas at Austin)

B3.3 Time: Saturday (11/4) 02:30 pm - 03:00 pm

Title: Nonlinear manifold reduced order models with domain decomposition

Presenter: Alejandro Diaz

Affiliation: Rice University

Abstract: This presentation discusses the integration of nonlinear-manifold reduced order models (NM-ROMs) with domain decomposition (DD). NM-ROMs approximate the full order model (FOM) state in a nonlinear-manifold by training a shallow, sparse autoencoder using FOM snapshot data. These NM-ROMs can be advantageous over linear-subspace ROMs (LS-ROMs) for problems with slowly decaying Kolmogorov n-width. However, the number of NM-ROM parameters that need to be trained scales with the size of the FOM. Moreover, for "extreme-scale" problems, the storage of

high-dimensional FOM snapshots alone can make ROM training expensive. To alleviate the training cost, DD is applied to the FOM, NM-ROMs are computed on each subdomain, and are coupled to obtain a global NM-ROM. This approach has several advantages: Subdomain NM-ROMs can be trained in parallel, involve fewer parameters to be trained than global NM-ROMs, require smaller subdomain FOM dimensional training data, and can be tailored to subdomain-specific features of the FOM. The shallow, sparse architecture of the autoencoder used in each subdomain NM-ROM allows application of hyper-reduction (HR), reducing the complexity caused by nonlinearity and yielding computational speedup of the NM-ROM. The proposed DD NM-ROM with HR approach is numerically compared to a DD LS-ROM with HR on 2D steady-state Burgers' equation, showing an order of magnitude improvement in accuracy of the proposed DD NM-ROM over the DD LS-ROM.

Authors: Alejandro N. Diaz (Rice University), Youngsoo Choi (Lawrence Livermore National Laboratory), and Matthias Heinkenschloss (Rice University)

B3.4 Time: Saturday (11/4) 03:00 pm - 03:30 pm

Title: Predictive digital twins for the structural health monitoring of civil structures

Presenter: Marco Tezzele

Affiliation: The University of Texas at Austin

Abstract: A digital twin (DT) is a virtualization of a physical asset built upon a set of computational models that dynamically update to persistently mirror a unique asset of interest throughout its operational lifespan, enabling informed decisions that realize value. In this talk, we address the health monitoring, maintenance and management planning of civil structures from a digital twin perspective. The asset-twin coupled dynamical system is encoded by means of a probabilistic graphical model which provides a general framework to carry out data assimilation, state estimation, prediction, planning, and learning. The assimilation of vibration response data is carried out by exploiting deep learning models, which allow automated selection and extraction of optimized damage-sensitive features and real-time assessment of the structural state of a bridge. We show how to incorporate in the DT framework high-dimensional multivariate time series describing the sensor measurements, while tracking the associated uncertainties. The proposed framework is made computationally efficient through a preliminary offline phase that involves: (i) The population of training datasets through reduced-order numerical models, exploiting the physics-based knowledge about the system response. (ii) The training of the structural health monitoring deep learning models, to automatically select and extract damage-sensitive features from raw high-dimensional vibration recordings, and ultimately relate them with the corresponding structural state. (iii) The computation of a health-dependent control policy mapping the belief over the digital state onto actions feeding back to the physical asset.

Authors: Matteo Torzoni (Politecnico di Milano), Marco Tezzele (The University of Texas at Austin), Stefano Mariani (Politecnico di Milano), Andrea Manzoni (Politecnico di Milano), Karen E. Willcox (The University of Texas at Austin)

MS30: Explorations in Topological Data Analysis

Organizers: Marco Campos (University of Houston) and William Ott (University of Houston)
Time: Friday (11/3) 03:00 pm - 05:00 pm, Saturday (11/4) 09:45 am - 11:45 am
Venue: Griffin 144

B1.1 Time: Friday (11/3) 03:00 pm - 03:30 pm

Title: Relative Growth as a Topological Graph Invariant

Presenter: Astrit Tola

Affiliation: University of Texas at Dallas

Abstract: Graphs are a prevalent form of data in various domains ranging from social networks to bioinformatics. Because of its wide range of applications, graph representation learning has become a predominant area in machine learning. However, current techniques often hinge on neural networks, which can prove costly and unfeasible when dealing with substantial graph datasets. In this study, we simplify a key idea of topological data analysis, filtration, to introduce a new graph invariant, relative growth, which computes the evolution rate of substructures of the graph induced by a user-defined function on nodes or edges. Our experiments demonstrate that our new representation can be used in supervised learning to outperform or give toe-to-toe results with state-of-the-art deep learning and topological models in graph classification benchmark datasets. Further, using only two parameters, the relative growth can also be considered as a powerful dimensionality reduction technique, which provides the first effective method for graph dataset visualization.

Authors: Astrit Tola (University of Texas at Dallas), Mary Taiwo (University of Manitoba), Cuneyt Akcora (University of Manitoba), Baris Coskunuzer (University of Texas at Dallas)

B1.2 Time: Friday (11/3) 03:30 pm - 04:00 pm

Title: Topological Data Analysis in Medical Imaging

Presenter: Brighton Nuwagira

Affiliation: University of Texas at Dallas

Abstract: Topological data analysis (TDA) is a mathematical framework that analyzes the shape and structure of complex datasets. It provides a way to extract meaningful information from high-dimensional data and has applications in various fields from material science to finance. In medical imaging, in the past decade, TDA has been widely used for medical image segmentation and registration, computer-aided diagnosis, and several other problems. In this study, we evaluated the TDA methods in 18 different 2D and 3D medical image datasets (MedMNIST) from various domains for computer-aided diagnosis and compare the performances with the DL methods. Furthermore, we evaluate the effect of the resolution of images on the performance of TDA methods by applying them to both low-resolution and high-resolution versions of the same datasets. We observe that TDA methods give competitive results with state-of-the-art deep learning models in some cases while falling behind in others. Our results suggest that extracted topological features can be used as a powerful ingredient for future DL models in several medical domains.

Authors: Brighton Nuwagira (University of Texas at Dallas)

B1.3 Time: Friday (11/3) 04:00 pm - 04:30 pm

Break/Discussion

B1.4 Time: Friday (11/3) 04:30 pm - 05:00 pm

Break/Discussion

B2.1 Time: Saturday (11/4) 09:45 am - 10:15 am

Title: Survival Analysis for Topological Data Analysis Features

Presenter: Asim Dey

Affiliation: University of Texas El Paso

Abstract: The interest in topological data analysis and its application in various fields has grown exponentially in recent years. Although all the developments in this area are well theoretically grounded, most of them lack the foundation for statistical inference. Most topological data analysis features have the stability property. However, they don't have statistical consistency, which guarantees the convergence of results for a large sample size. In this study, we adopt methods from statistical survival analysis to evaluate topological data analysis features. The consistency of the survival analysis tools is well established; therefore, they automatically bring consistency results in the topological data analysis.

Authors: Asim Dey

B2.2 Time: Saturday (11/4) 10:15 am - 10:45 am

Title: Evader Detection In 3-Dimensional Mobile Sensor Networks

Presenter: Kyle Williams

Affiliation: University of Houston

Abstract: Consider a sensor network in which sensors with ball shaped detection regions roam a given domain. An evasion path is a continuous path that avoids detection by these sensors. Techniques from topological data analysis (TDA) have been applied to develop sufficient conditions for the detection of evasion paths in 2D in a coordinate-free way. These conditions assume the alpha-complex of the sensor network undergoes only a fixed set of changes. We study two questions, how do the dynamics of the sensor movement affect the topology and performance of the sensor network. Second, how can these conditions be adapted to sensors in three dimensions and how likely are each of these changes to occur?

Authors: Kyle Williams, William Ott, Henry Adams, Marco Campos

B2.3 Time: Saturday (11/4) 10:45 am - 11:15 am

Title: Configuration Spaces of Metric Graphs with Restraint Parameters

Presenter: Wenwen Li

Affiliation: Hobart and William Smith Colleges

Abstract: Configuration space is a concept used in robot motion planning. In the case of arranging n robots in a warehouse X, a configuration is a possible arrangement of those robots in X when we treat robots as points. The space that contains all possible configurations is called the n-th configuration space of X. In the real-world scenario, however, there is a minimal nonzero distance r_{ij} allowed between each pair of robots i and j. The space that contains all possible arrangements of n robots is called the n-th configuration space with the restraint parameter $r = (r_{ij})_{i \neq j}$, where r is an $n(n-1)/2$-dimensional vector. In this talk, I will give a brief introduction to the n-th configuration space with the restraint parameter r and multiparameter persistence theory. I will then present joint work with Murad Ozaydin on the 2-parameter persistence module raised from a double filtration of configuration spaces of metric graphs with parameters r and l.

Authors: Wenwen Li (Hobart and William Smith Colleges) and Murad Ozaydin (University of Oklahoma)

B2.4 Time: Saturday (11/4) 11:15 am - 11:45 am

Title: Hausdorff vs Gromov-Hausdorff distances

Presenter: Henry Adams

Affiliation: University of Florida

Abstract: Though Gromov-Hausdorff distances between metric spaces are a common concept in data analysis, these distances are hard to compute. If X and Y are two sufficiently dense subsets of a closed Riemannian manifold M, then we lower bound the Gromov-Hausdorff distance between X and Y by $\frac{1}{2}$ the difference between the Hausdorff distances from X to M and from Y to M. The constant $\frac{1}{2}$ can be improved depending on the dimension and curvature of the manifold M, and obtains the optimal value 1 in the case of the circle. Our proofs begin by converting discontinuous functions between metric spaces into simplicial maps between Čech complexes. We then produce topological obstructions to the existence of such maps using the nerve lemma and the fundamental class of a manifold.

Authors: Henry Adams (University of Florida), Florian Frick (Carnegie Mellon University), Sushovan Majhi (George Washington University), Nicholas McBride (UC Santa Cruz)

MS31: Stochastic Methods in Gene Regulation and Spatial Dynamics

Organizers: Bhargav R. Karamched (Florida State University) and William Ott (University of Houston)
Time: Saturday (11/4) 01:30 pm - 03:30 pm
Venue: Oliver 119A

B3.1 Time: Saturday (11/4) 01:30 pm - 02:00 pm

Title: Noisy delay denoises biochemical oscillators

Presenter: William Ott

Affiliation: University of Houston

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, translation, folding, and translocation. 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 unexpectedly 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.

Authors: Yun Min Song (KAIST), Sean Campbell (University of Houston), LieJune Shiau (University of Houston Clear Lake), Jae Kyoung Kim (KAIST), and William Ott (University of Houston)

B3.2 Time: Saturday (11/4) 02:00 pm - 02:30 pm

Title: Stochastic Switching of Delayed Feedback Suppresses Oscillations in Genetic Regulatory Systems

Presenter: Bhargav Karamched

Affiliation: Florida State University

Abstract: Delays and stochasticity have both served as crucially valuable ingredients in mathematical descriptions of control, physical and biological systems. In this work, we investigate how explicitly dynamical stochasticity in delays modulates the effect of delayed feedback. To do so, we consider a hybrid model where stochastic delays evolve by a continuous-time Markov chain, and between switching events, the system of interest evolves via a deterministic delay equation. Our main contribution is the calculation of an effective delay equation in the fast switching limit. This effective equation maintains the influence of all subsystem delays and cannot be replaced with a single effective delay. To illustrate the relevance of this calculation, we investigate a simple model of stochastically switching delayed feedback motivated by gene regulation. We show that sufficiently fast switching between two oscillatory subsystems can yield stable dynamics.

Authors: Bhargav Karamched and Christopher Miles

B3.3 Time: Saturday (11/4) 02:30 pm - 03:00 pm

Title: A Subdiffusive Analysis of Transcription Factor Binding Kinetics

Presenter: Amanda M. Alexander

Affiliation: University of Houston

Abstract: Experiments show that molecules inside biological cells often exhibit anomalous subdiffusion instead of normal diffusion. Whereas reaction-diffusion equations are a well-known area of research in mathematical biology, the analogous reaction-subdiffusion equations are understudied. We develop a subdiffusive model of the Fluorescence Recovery After Photobleaching (FRAP) experiment, which is often used to measure intracellular reaction-diffusion kinetics. We then show that our subdiffusive model fits FRAP data from glucocorticoid receptors in a cell nucleus as well as a previously established diffusive model. Additionally, our model predicts binding kinetics that are dramatically different from previous results.

Authors: Amanda M. Alexander (University of Houston) and Sean D. Lawley (University of Utah)

B3.4 Time: Saturday (11/4) 03:00 pm - 03:30 pm

Title: Extreme first passage times for populations of identical rare events

Presenter: Jay Newby

Affiliation: University of Alberta

Abstract: A collection of identical and independent rare event first passage times is considered. The problem of finding the fastest out of N such events to occur is called an extreme first passage time. The rare event times are singular and limit to infinity as a positive parameter scaling the noise magnitude is reduced to zero. In contrast, previous work has shown that the mean of the fastest event time goes to zero in the limit of an infinite number of walkers. The combined limit is studied. In particular, the mean time and the most likely path taken by the fastest random walker are investigated. Using techniques from large deviation theory, it is shown that there is a distinguished limit where the mean time for the fastest walker can take any positive value, depending on a single proportionality constant. Furthermore, it is shown that the mean time and most likely path can be approximated using the solution to a variational problem related to the single-walker rare event.

Authors: James Maclaurin and Jay Newby

MS32: Dynamics of Mathematical Models in Biology

Organizers: Mohammad Mihrab Uddin Chowdhury (Texas Tech University) and Angela Peace (Texas Tech University) and Lale Asik (University of the Incarnate Word)

Time: Saturday (11/4) 09:45 am - 11:45 am
Venue: Griffin 204

B2.1 Time: Saturday (11/4) 09:45 am - 10:15 am

Break/Discussion

B2.2 Time: Saturday (11/4) 10:15 am - 10:45 am

Title: Improved Graph Based Statistical Clustering Techniques with Application to Breast Cancer Image Segmentation

Presenter: Fahad Mostafa

Affiliation: Texas Tech University

Abstract: Graphs are commonly used to represent connected data in various domains including medical imaging, social systems, ecosystems, and information systems. With the growth of artificial intelligence technologies, there is a growing interest in graph learning or machine learning on graphs, among researchers and practitioners. Graph learning from networks is expensive and sometimes misleading in clustering for high-dimensional datasets such as cancer histology image data set. We present a new and scalable approach for graph clustering, named preconditioned inverse power iteration clustering (PIPIC) with preconditioned Laplacian matrices from graph learning. It utilizes truncated power iteration on a normalized pairwise similarity matrix of the data to obtain a low-dimensional embedding of the dataset, which is an effective cluster indicator. PIPIC shows superior performance to commonly used spectral methods like Spectral Clustering (SC) on real datasets and can run efficiently on large datasets with preconditioning. The PIPIC algorithm runs significantly faster than the state-of-the-art SC and PIC implementations based on the eigenvector computation technique, with a speedup of over a thousand times. Modified Laplacian-based clustering shows better clustering than original embeddings.

Authors: Fahad Mostafa (Texas Tech University), Victoria Howle (Texas Tech University)

B2.3 Time: Saturday (11/4) 10:45 am - 11:15 am

Title: Investigating Patterns of Disease Emergence in Stochastic Epidemic Models with Seasonality

Presenter: Mahmudul Bari Hridoy

Affiliation: Department of Mathematics and Statistics, Texas Tech University

Abstract: Changes in contacts during the school year or summer months and the effect of temperature or humidity on disease susceptibility are some of the proposed reasons for seasonal occurrence of infectious disease outbreaks. In order to formulate effective strategies for disease prevention and control, it is essential to comprehend the primary factors driving seasonal fluctuations and their interconnected dynamics. We examine how seasonal variation in transmission, recovery, or dispersal rates, their magnitude and seasonal synchrony or asynchrony impact the probability of disease extinction and time to disease extinction in several well-known continuous-time Markov chain (CTMC) SIR, SEIR multi-patch, and vector-host epidemic models. An ODE framework which incorporates periodic parameters for transmission, recovery, or dispersal serves as a basis for each stochastic model. The basic reproduction numbers and seasonal reproduction numbers from the ODE and branching process approximations of the CTMC are useful in predicting some of the stochastic behavior of the CTMC epidemic models. In particular, we apply these techniques to estimate a time-periodic probability of disease extinction, or equivalently, the probability of no disease emergence at the initiation of an epidemic. We also test the branching process approximations against

simulations of the full CTMC epidemic models. The numerical outcomes show that seasonal variation in transmission, recovery, or dispersal generally increases the probability of disease extinction (reducing disease emergence), and the shape of the seasonal reproduction number provides information about the shape of the periodic probability of disease extinction. However, extrema of seasonal probability of extinction precede those predicted by the instantaneous probability of extinction, a.k.a the "winter is coming" effect. These findings pave the way for the implementation of more effective disease mitigation strategies.

Authors: Mahmudul Bari Hridoy (Texas Tech University) and Linda J. S. Allen (Texas Tech University)

B2.4 Time: Saturday (11/4) 11:15 am - 11:45 am

Title: Identifiability of compartment models for infectious diseases under both perfect and flawed data

Presenter: Tingting Tang

Affiliation: San Diego State University

Abstract: Compartment modeling has been used extensively in epidemics to understand and predict infectious diseases. With the increasing data availability, mathematical models fit cumulative data are used to estimate disease key transmission parameters. During this process, one important question arises regarding the model identifiability which handles the question of whether parameters can be correctly and accurately recovered given available data. In this talk, I will demonstrate the problems in incidence data accuracy with Covid 19 cases in Imperial Vally. Then, I use both a simple SEIR model and a SI vector-host model to demonstrate the impact of data type, data resolution, and optimization tools used in parameter estimation in accessing models' identifiability.

Authors: Tingting Tang (San Diego University)

MS33: Mathematical and computational foundations of predictive digital twins

Organizers: Lianghao Cao (University of Texas at Austin) and Dingcheng Luo (University of Texas at Austin) and Bassel Saleh (University of Texas at Austin)
Time: Friday (11/3) 03:00 pm - 05:00 pm, Saturday (11/4) 09:45 am - 11:45 am
Venue: Griffin 305

B1.1 Time: Friday (11/3) 03:00 pm - 03:30 pm

Title: Adaptive Gaussian Process Modeling for Trajectory Optimization with Model Inexactness

Presenter: Jonathan Cangelosi

Affiliation: Rice University

Abstract: In many applications one must compute optimal trajectories from imperfect knowledge of the dynamics. For example, solving trajectory optimization problems for hypersonic vehicles requires the computation of lift and drag coefficients at many flight configurations. Determining these coefficients requires expensive high-fidelity computations using detailed representations of the hypersonic vehicle. This talk proposes the use of computationally inexpensive adaptive Gaussian process models constructed from high-fidelity samples to approximate the components of the dynamics that are expensive to evaluate. To reduce the effect of model errors on the optimal trajectory, the current Gaussian process model is updated as needed at the cost of evaluating the components

of the dynamics at a small number of additional sample points. First, the optimal control problem is solved using the mean of the current Gaussian process model to represent the dynamics. Next, sensitivity analysis is combined with properties of the Gaussian process model, such as its variance, to determine whether the Gaussian process model needs to updated, and if so, at which samples the dynamics should be evaluated to update the Gaussian process model. This talk outlines our current model refinement procedure and demonstrates its performance on a trajectory optimization problem for a hypersonic vehicle with lift and drag models that are known, but expensive to evaluate.

Authors: Jonathan Cangelosi (Rice University) and Matthias Heinkenschloss (Rice University)

B1.2 Time: Friday (11/3) 03:30 pm - 04:00 pm

Title: Exploiting Structure via Nested Operator Inference in Physics-Based Learning

Presenter: Nicole Aretz

Affiliation: The University of Texas at Austin

Abstract: Highly accurate full-order models (FOMs) are often too expensive computationally to evaluate in predictive, real-time applications. For digital twins, this restriction can make time-sensitive decisions difficult, especially when fallback options simplify physical dynamics to arrive at the necessary speed. Projection-based model order reduction methods exploit the intrinsic low-dimensionality of the full-order solution manifold. These reduced-order models (ROMs) typically 1) achieve significant computational savings in the order of several magnitudes, 2) guarantee approximation accuracy through established error theory, and 3) remain interpretable through the governing physical equations. However, constructing ROMs via projection requires access to the full-order operators - a significant shortcoming for large-scale applications with legacy codes or commercial solvers. Operator Inference circumvents this requirement by learning the intrusive ROM from available full-order data and the structure of the governing equations. In this talk we present a nested variant of Operator Inference which can significantly reduce the data requirement and the need for regularization.

Authors: Nicole Aretz (The University of Texas at Austin) and Karen Willcox (The University of Texas at Austin)

B1.3 Time: Friday (11/3) 04:00 pm - 04:30 pm

Title: Role of Hyper-Reduction in Enhancing the Efficacy of Digital Twins

Presenter: Suparno Bhattacharyya

Affiliation: Texas A&M University

Abstract: With the advent of digital twin (DT) technology–virtual counterparts of physical systems used for real-time monitoring and analysis–the need for fast and accurate simulations has increased dramatically. A major obstacle in implementing DT's stem from the fact that accuracy comes with a hefty cost associated with simulating the complex physical system in a timely manner suitable for real-time actions. One way to mitigate such problem is by means of approximating the physical system with an equivalent fast proxy, but at the same time enabling accurate solutions. Reduced Order Models (ROMs) have been instrumental in improving computational efficiency for such large-scale systems, offering potential uses in DT's. In contemporary computational disciplines, particularly within nuclear engineering and fluid flow systems, the primary challenge is managing simulations with high-dimensional dynamics and pronounced non-linearities. These models–like the Radiation Transport models in nuclear reactors and Flow and Transport models in porous media–are inherently high-dimensional and/or nonlinear, consuming vast computational resources. ROMs simplify the task by projecting the original, high-dimensional equations onto a more manageable, lower-dimensional subspace. Techniques such as Proper Orthogonal Decomposition are often employed for this purpose, ensuring that the core dynamics are retained, but in many cases it fails to provide reasonable speedups owing to the computation of the nonlinearities, or the inability of performing an affine decomposition of operators in matrix-free solvers. Hyper-reduction, i.e., a way to circumvent the issue with nonlinearities, is often used. This presentation will spotlight two Hyper-reduction methodologies: the Energy Conserving Mesh Sampling (ECSW) and the Discrete Empirical Interpolation Method (DEIM). Positioned as advanced ROM strategies, these hyper-reduction techniques are tailored to maximize computational efficiency, especially when dealing with non-linearities. When paired with digital twins, ECSW and DEIM have the potential to significantly bolster both computational efficiency and accuracy. Our early findings suggest that these methods can amplify the performance efficiency of ROMs. The implications of this research go beyond mere computational enhancement. As industries increasingly adopt digital twin technologies for system optimization, predictive maintenance, and instantaneous feedback, the inclusion of ECSW and DEIM approaches could significantly impact how we simulate, scrutinize, and forecast intricate system behaviors. This investigation underscores the pivotal role of Hyper-reduction techniques in not only expediting computational simulations but also in augmenting the real-world utility of digital twins in complex systems.

Authors: Suparno Bhattacharyya (Texas A&M University) and Jian Tao (Texas A&M University) and Eduardo Gildin (Texas A&M University) and Jean C. Ragusa (Texas A&M University)

B1.4 Time: Friday (11/3) 04:30 pm - 05:00 pm

Title: Can eXplainable-AI (XAI) Capture Robust Dynamical Relationships in Ice and Ocean Modeling?

Presenter: Shreyas Sunil Gaikwad

Affiliation: University of Texas at Austin

Abstract: Artificial Neural Networks (NNs) have been used increasingly in the climate sciences in the last decade due to their high efficiency and ability to capture non-linear physics and dynamics. These NNs have proven hard to interpret (black boxes), which is why there has been a hesitancy in their adoption for wider use. There is thus a growing need to develop trust in these models. To aid the interpretability of NNs, many methods have been recently developed within the growing field of eXplainable-AI (XAI). These methods come in various flavors, ranging across removal-based, gradient-based, and propagation-based explanations. There is even some recent work that looks specifically at XAI for regression (XAIR). While XAI methods can provide insights into correlations between inputs and outputs and hence inspire new science, they alone cannot prove the existence of causal forcings since they are not exposed to the underlying dynamics of the physical systems. Adjoints are powerful computational engines to efficiently compute dynamically consistent gradients or sensitivities of scalar-valued model output to high-dimensional model inputs. They can thus be used to validate the potential insights from XAI methods and check for the existence of teleconnections that can be interpreted by scientists. In this work, we contrast the relevance heatmaps derived from a post-hoc attribution XAI method - Layerwise Relevance Propagation (LRP) against the physics-based sensitivity maps derived from the adjoint of the MIT General Circulation Model (MITgcm). In doing so, we highlight the potential of such comparisons to benefit both research communities, allowing an improvement in NN architectures to give the correct predictions for the right reasons, as well as allowing domain experts to inspect new links suggested by XAI methods. We also highlight the utility of our new free and open-source adjoint for the MITgcm using the

open-source Automatic Differentiation (AD) tool Tapenade, helping make science more accessible to a wider group of researchers.

Authors: Shreyas Sunil Gaikwad (The University of Texas at Austin) and Helen Pillar (The University of Texas at Austin) and Jean-Michel Campin (Massachusetts Institute of Technology) and Sri Hari Krishna Narayanan (Argonne National Laboratory) and Laurent Hascoet (Institut National de Recherche en Informatique et Automatique) and Patrick Heimbach (The University of Texas at Austin)

B2.1 Time: Saturday (11/4) 09:45 am - 10:15 am

Title: Learning Reduced Operators with Gaussian Processes

Presenter: Shane A. McQuarrie

Affiliation: Sandia National Laboratories

Abstract: This work presents a data-driven method for learning reduced-order models whose predictions are endowed with uncertainty estimates. The operator inference approach to model reduction poses the problem of learning reduced-order model operators as a regression of state space data and corresponding time derivatives. When time derivative data are not natively available, as is often the case in applications, they must be estimated from the state data with, e.g., finite difference approximations. The accuracy of the estimation greatly affects the quality of the learned reduced-order model, hence learning accurate reduced-order models in this manner is challenging when available state data are sparse or noisy. Our approach incorporates Gaussian process surrogate modeling into the operator inference framework to (1) probabilistically describe uncertainties in the state data and (2) procure analytical time derivative estimates with uncertainty. The formulation leads to a generalized least-squares regression and, ultimately, reduced-order operators that are themselves defined probabilistically. The resulting model propagates uncertainties from the observed state data to reduced-order predictions.

Authors: Shane A. McQuarrie (Sandia National Laboratories) and Mengwu Guo (University of Twente) and Anirban Chaudhuri (The University of Texas at Austin)

B2.2 Time: Saturday (11/4) 10:15 am - 10:45 am

Title: Derivative-informed Deep Operator Network

Presenter: Yuan Qiu

Affiliation: Georgia Institute of Technology

Abstract: Deep operator networks, a class of neural operators that learn mappings between function spaces, have recently been developed as surrogate models for parametric partial differential equations (PDEs). In this talk, we introduce a derivative-informed deep operator network (DI-DeepONet), which leverages the derivative information of the solution operator of parametric PDEs to enhance the accuracy and efficiency of DeepONet. DI-DeepONet uses DeepONet as its backbone and incorporates two derivatives in the loss function for training, including the directional derivatives of the output function with respect to the input function and the gradient of the output function with respect to the physical domain variables. This feature enhances generalization accuracy, especially in scenarios with limited training data, and provides a more accurate approximation of derivatives. Additionally, we propose to use a reduced representation of the input functions (e.g., through projection into the Karhunen-Lo‘eve expansion subspace or the active subspace) rather than the full representation. The model-based dimension reduction of input functions allows us to train a much smaller neural network, thereby significantly reducing the computational cost for training and

the required volume of training data. We present the results of several numerical experiments to demonstrate the effectiveness of DI-DeepONet compared to DeepONet.

Authors: Yuan Qiu (Georgia Institute of Technology) and Nolan Bridges (Georgia Institute of Technology) and Peng Chen (Georgia Institute of Technology)

B2.3 Time: Saturday (11/4) 10:45 am - 11:15 am

Title: Incorporating Physics-Based Knowledge into Neural Differential Equations for the Modeling and Control of Robotic Systems

Presenter: Cyrus Neary

Affiliation: The University of Texas at Austin

Abstract: The inclusion of physics-based knowledge into learned models of dynamical systems can greatly improve their data efficiency and generalization. Such a priori knowledge might arise from physical principles (e.g., conservation laws) or the system's design (e.g., the Jacobian matrix of a robot), even if large portions of the system dynamics remain unknown. We develop a framework to learn uncertainty-aware dynamics models from trajectory data while incorporating such a priori system knowledge as inductive bias. We demonstrate the capabilities of the proposed models through experiments on simulated robotic systems, as well as by using them to model and control a hexacopter's flight dynamics: A neural stochastic differential equation trained using only three minutes of manually collected flight data results in a model-based control policy that accurately tracks aggressive trajectories that push the hexacopter's velocity and Euler angles to nearly double the maximum values observed in the training dataset. Beyond improving data efficiency, we additionally use this framework to define a compositional approach to learning. Neural network submodels are trained on data generated by relatively simple subsystems, and the dynamics of more complex composite systems are then predicted without requiring additional data generated by the composite systems themselves.

Authors: Cyrus Neary (The University of Texas at Austin) and Franck Djeumou (The University of Texas at Austin) and Eric Goubault (LIX, CNRS, Ecole Polytechnique, Institut Polytechnique de Paris) and Sylvie Putot (LIX, CNRS, Ecole Polytechnique, Institut Polytechnique de Paris) and Ufuk Topcu (The University of Texas at Austin)

B2.4 Time: Saturday (11/4) 11:15 am - 11:45 am

Title: Modeling the Open Probability of Ion Channels on Cell/Organelle Membranes using Deep Neural Networks

Presenter: Qingguang Guan

Affiliation: University of Southern Mississippi

Abstract: Many biological processes are modeled using differential equations. However, determining the underlying equations analytically becomes highly challenging due to the complexity and unknown factors inherent in these biological processes. Our research aims to employ deep neural networks (DNNs) to model the open probability of ion channels, a task that can prove to be intricate when tackled with ordinary differential equations (ODEs). The distinctive contribution of this research lies in reducing the number of unknowns required to model the open probability. When trained with valid data, the same neural network architecture can be employed for different ion channels, such as sodium, potassium, and calcium. Subsequently, we integrated the DNN model into calcium dynamics in neurons with endoplasmic reticulum, resulting in a hybrid model that combines partial differential equations (PDEs) and deep neural networks. Numerical results are provided to demonstrate the accuracy and flexibility of the PDE-DNN model.

Authors: Abel Gurung (University of Southern Mississippi) and Qingguang Guan (University of Southern Mississippi)

MS34: Recent advances in modeling and analysis of biological dynamics

Organizers: Md Sajedul Islam (UL Lafayette) and Jenita Jahangir (UL Lafayette) and Amy Veprauskas (UL Lafayette)
Time: Saturday (11/4) 03:45 pm - 04:45 pm, Sunday (11/5) 09:45 am - 10:45 am, Sunday (11/5) 11:00 am - 01:00 pm
Venue: Oliver 119A

B4.1 Time: Saturday (11/4) 03:45 pm - 04:15 pm

Title: Phytoplankton competition for nutrients and light in a stratified lake: A mathematical model connecting epilimnion and hypolimnion

Presenter: Jude Kong

Affiliation: York University

Abstract: In this talk, I will present several mathematical models describing the vertical distribution of phytoplankton in the water column. In particular, I will introduce a new mathematical model connecting epilimnion and hypolimnion to describe the growth of phytoplankton limited by nutrients and light in a stratified lake. Stratification separates the lake with a horizontal plane called thermocline into two zones: epilimnion and hypolimnion. The epilimnion is the upper zone which is warm (lighter) and well-mixed, and the hypolimnion is the bottom colder zone which is usually dark and relatively undisturbed. The growth of phytoplankton in the water column depends on two essential resources: nutrients and light. The critical thresholds for the settling speed of phytoplankton cells in the thermocline and the loss rate of phytoplankton are established, which determine the survival or extirpation of phytoplankton in epilimnion and hypolimnion.

Authors: Jude Kong (York University)and Jimin Zhang (Heilongjiang University) and Junping Shi (William & Mary) and Hao Wang (University of Alberta)

B4.2 Time: Saturday (11/4) 04:15 pm - 04:45 pm

Title: Asymptotic profiles of the steady state for a diffusive SIS epidemic model with Dirichlet boundary conditions

Presenter: Keng Deng

Affiliation: University of Louisiana at Lafayette

Abstract: In this paper, we consider a spatial SIS reaction-diffusion model with Dirichlet boundary conditions. We study the asymptotic profiles of the endemic equilibrium for small and large diffusion rates of the susceptible individuals and the infected individuals. Compared to similar models with Neumann boundary conditions, our results indicate that the hostile exterior environment makes a distinct impact on the spread of infectious diseases.

Authors: Keng Deng (University of Louisiana at Lafayette)

B4.3 Time: Sunday (11/5) 09:45 am - 10:15 am

Title: Global Dynamics of Discrete Mathematical Models of Tuberculosis

Presenter: Saber Elaydi

Affiliation: Trinity University

Abstract: In this talk, we develop discrete models of Tuberculosis (TB). This includes SEI endogenous and exogenous models without treatment. These models are then extended to a SEIT model with treatment. We introduce two types of net reproduction numbers: the traditional $\mathcal{R}_0$ based on the disease-free equilibrium, and a new net reproduction number $\mathcal{R}_0(\mathcal{E}^*)$ based on the endemic equilibrium. We show that the disease-free equilibrium is globally asymptotically stable if $\mathcal{R}_0 \leq 1$ and unstable if $\mathcal{R}_0 > 1$. Moreover, the endemic equilibrium is locally asymptotically stable if $\mathcal{R}_0(\mathcal{E}^*) < 1 < \mathcal{R}_0$.

Authors: Saber Elaydi (Trinity University) and René Lozi (Laboratory J.A. Dieudonné, CNRS, Université Côte d'Azur)

B4.4 Time: Sunday (11/5) 10:15 am - 10:45 am

Title: Temperature-Dependent Competitive Dynamics of Two Invasive Mosquito Species in Larval Stage

Presenter: Nusrat Tabassum

Affiliation: Texas Tech University

Abstract: Viral diseases like dengue, Zika, and chikungunya are spread by two invasive mosquito species, *Aedes aegypti* and *Aedes albopictus.* These species are capable of reproducing in a variety of container habitats, and their ability to successfully colonize new regions is linked to their competition for resources. This competition may affect the distribution and abundance of these species, which in turn can influence the transmission of mosquito-borne diseases. Therefore, this study aims to explore the effects of environmental factors such as temperature and population density on the competitive dynamics between these two species. We have developed a stage-structured mosquito larval competition model to investigate the competition between mosquito larvae under different temperatures. We analyzed the stability of the equilibrium points of the model under different climatic scenarios, which can lead to either a competitive exclusion or coexistence of the species. The models inter and intra-specific competition parameters were fitted using laboratory data. We also conducted a sensitivity analysis to determine the parameters to which our model is most responsive. By improving our understanding of how mosquito larval competition shifts in response to various environmental conditions, we can more accurately predict and respond to outbreaks of mosquito-borne diseases.

Authors: Nusrat Tabassum (Texas Tech University) and Kyle Dahlin (Virginia Tech) and Amanda N. Laubmeier (Texas Tech University)

B5.1 Time: Sunday (11/5) 11:00 am - 11:30 am

Title: The dynamics of a discrete-time predator-prey model with predator evolution and periodic prey reproduction

Presenter: Neerob Basak and Narendra Pant

Affiliation: University of Louisiana at Lafayette

Abstract: We extend the predator-prey model developed by Ackleh et al. (2019) to study the evolution of a predator to resist toxicant effects and periodic reproduction in the prey due to seasonality. Assuming a trade-off between toxicant resistance and the ability of the predator to capture prey, we first model the predator's evolution to resist the effect of toxicants. We analyze the dynamics of the proposed model and compare our findings with the results of Ackleh et al. (2019), where it was assumed that the prey evolves to resist toxicants. Then, we consider an additional model extension in which prey reproduction is given by a two-periodic function that represents seasonal breeding. We study the local stability of periodic solutions, establish the persistence of the system, and show that the model attains an interior two-cycle. We again compare our results with those in Ackleh et al. (2019), which assumed the reproduction to be continuous.

Authors: Azmy S. Ackleh (University of Louisiana at Lafayette) and Neerob Basak (University of Louisiana at Lafayette) and Narendra Pant (University of Louisiana at Lafayette) and Amy Veprauskas (University of Louisiana at Lafayette)

B5.2 Time: Sunday (11/5) 11:30 am - 12:00 pm

Title: Amphibian Fungal Pathogen: Unravelling the BSal Epidemic Across the Life Stages of Salamanders

Presenter: Mohammad Mihrab Uddin Chowdhury

Affiliation: Texas Tech University

Abstract: The transmission dynamics of infectious diseases in amphibians, particularly those with multiple transmission routes, pose a complex ecological challenge. In this study, we employ mathematical modeling techniques to investigate the intricate transmission dynamics of infectious diseases in amphibians, with a specific emphasis on Batrachochytrium Salamandrivorans (Bsal), a fungal pathogen that impacts North American Salamander populations. Our analysis comprehensively considers various influential factors, including pathogen loads, population densities, and temperature fluctuations. The life cycle dynamics of the host population are characterized by distinct life stages, including larvae, efts, and adults, each exhibiting unique growth patterns and habitat preferences. To elucidate the dynamics of Bsal transmission within salamander populations, we construct a compartmental model employing ordinary differential equations that account for life cycle and disease dynamics. Through model simulations and rigorous analyses, this study provides valuable insights into potential control strategies to mitigate transmission and avert epidemic outbreaks of Bsal among North American salamander populations.

Authors: Mohammad Mihrab Uddin Chowhdury (Texas Tech University)and Matt Gray (University of Tennessee, Knoxville) and Angela Peace (Texas Tech University)

B5.3 Time: Sunday (11/5) 12:00 pm - 12:30 pm

Title: Synchronization of Clusters of Pulse Coupled Oscillators with Synaptic Delays

Presenter: Ananth Vedururu Srinivas

Affiliation: Louisiana State University Health Sciences Center, New Orleans

Abstract: Phase resetting Curves (PRCs) have been useful in determining and analyzing various phase-locking modes in oscillatory neurons under pulse-coupling assumption. Previously, our group used PRCs to determine the stability of synchrony both within and between clusters of neural oscillators, considering within and between cluster terms separately, without synaptic delays. Subsequently, the interactions of the within and between cluster terms were considered, demonstrating how an alternating firing pattern between clusters could stabilize within cluster synchrony even in clusters unable to synchronize themselves in isolation. Later, criteria were derived for synchrony between two pulse-coupled oscillators with synaptic delays. In this study, we derived stability criteria for synchrony in one and two clusters of pulse-coupled oscillators by including delays in transmission of inputs between oscillators. We demonstrated the validity of these results using a map of firing intervals based on the PRC. We used self-connected neurons to represent clusters and therefore derived conditions under which a neuron can phase-lock itself with a delayed input. For one cluster,

we used a realistic model of fast-spiking PV+ interneurons in the medial entorhinal cortex. For the other, we used an RTM model of an excitatory neuron. Although this analysis only strictly applies to identical neurons receiving identical synapses from the same number of neurons, the principles are general and can be used to understand how to promote or impede synchrony in physiological networks of neurons. The results from this work can help understand how excitatory neurons promote synchrony in the network of fast-spiking neurons.

Authors: Ananth Vedururu Srinivas (LSU Health New Orleans) and Carmen C. Canavier (LSU Health New Orleans)

B5.4 Time: Sunday (11/5) 12:30 pm - 01:00 pm

Title: A Discrete-time stage-structured host-parasitoid model with combinations of various pest control strategies

Presenter: Jenita Jahangir

Affiliation: University of Louisiana at Lafayette

Abstract: We propose a discrete-time host-parasitoid model with stage structure in both species. For this model, we establish conditions for the existence and global stability of the extinction and parasitoid-free equilibria as well as conditions for the existence and local stability of an interior equilibrium and system persistence. We study the model numerically to examine how pesticide spraying may interact with natural enemies (parasitoids) to control the pest (host) species. We then extend the model to an impulsive difference system that incorporates both periodic pesticide spraying and augmentation of the natural enemies to suppress the pest population. For this system, we determine when the pest-eradication periodic solution is globally attracting. We also examine how varying the control measures (pesticide concentration, natural enemy augmentation, and the frequency of applications) may lead to different pest outbreak or persistence outcomes when eradication does not occur.

Authors: Azmy S. Ackleh (University of Louisiana at Lafayette) and Jenita Jahangir (University of Louisiana at Lafayette) and Amy Veprauskas (University of Louisiana at Lafayette)

Mini-Symposium Presentations in Chronological Order

B1: Friday (11/3) 03:00 pm - 05:00 pm

B1.1: Friday (11/3) 03:00 pm - 03:30 pm

- Justin Swain (MS02, Griffin 301, page 13)
- Aaron Welters (MS04, Griffin 302, page 22)
- Tiffany Frugé Jones (MS05, Griffin 129, page 26)
- Beatrice Riviere (MS07, Griffin 130, page 32)
- Jimmie Adriazola (MS11, Oliver 112, page 45)
- J.M. Landsberg (MS14, Griffin 201, page 57)
- Hayriye Gulbudak (MS25, Oliver 117, page 83)
- Thomas Hagstrom (MS26, Oliver 116, page 87)
- Vinicio Rios (MS27, Griffin 203, page 90)
- Travis B. Thompson (MS28, Oliver 101, page 92)
- Astrit Tola (MS30, Griffin 144, page 98)
- Jonathan Cangelosi (MS33, Griffin 305, page 103)

B1.2: Friday (11/3) 03:30 pm - 04:00 pm

- Yimin Lin (MS02, Griffin 301, page 13)
- Robert Viator Jr. (MS04, Griffin 302, page 23)
- Eduardo Servin Torres (MS05, Griffin 129, page 26)
- Davood Damircheli (MS07, Griffin 130, page 32)
- Hewan Shemtaga (MS11, Oliver 112, page 45)
- Abeer Al Ahmadieh (MS14, Griffin 201, page 57)
- Leah LeJeune (MS25, Oliver 117, page 84)
- Pavel Lushnikov (MS26, Oliver 116, page 87)
- Safeyya Alyahia (MS27, Griffin 203, page 91)
- Charles Puelz (MS28, Oliver 101, page 93)

- Brighton Nuwagira (MS30, Griffin 144, page 98)
- Nicole Aretz (MS33, Griffin 305, page 104)

B1.3: Friday (11/3) 04:00 pm - 04:30 pm

- Juntao Huang (MS02, Griffin 301, page 14)
- Stephen P. Shipman (MS04, Griffin 302, page 23)
- Yunhui He (MS05, Griffin 129, page 26)
- Loic Cappanera (MS07, Griffin 130, page 32)
- John Zweck (MS11, Oliver 112, page 46)
- Chia-Yu Chang (MS14, Griffin 201, page 57)
- Joshua Macdonald (MS25, Oliver 117, page 84)
- Paul Blochas (MS26, Oliver 116, page 88)
- Jackson Knox (MS27, Griffin 203, page 91)
- Bradley Vigil (MS28, Oliver 101, page 93)
- Suparno Bhattacharyya (MS33, Griffin 305, page 104)

B1.4: Friday (11/3) 04:30 pm - 05:00 pm

- An Vu (MS02, Griffin 301, page 14)
- Seth Gerberding (MS04, Griffin 302, page 23)
- Olaniyi Samuel Iyiola (MS05, Griffin 129, page 27)
- Jiaqi Li (MS07, Griffin 130, page 33)
- Mat Johnson (MS11, Oliver 112, page 46)
- Joe Kileel (MS14, Griffin 201, page 58)
- Cameron Browne (MS25, Oliver 117, page 85)
- Zequn Zheng (MS27, Griffin 203, page 92)
- Adrian Celaya (MS28, Oliver 101, page 93)
- Shreyas Sunil Gaikwad (MS33, Griffin 305, page 105)

B2: Saturday (11/4) 09:45 am - 11:45 am

B2.1: Saturday (11/4) 09:45 am - 10:15 am

- Shiming Yuan (MS01, Griffin 129, page 11)
- Wei Guo (MS02, Griffin 301, page 15)
- Junshan Lin (MS04, Griffin 302, page 24)
- Jesse Chan (MS07, Griffin 130, page 33)
- Anna Ghazaryan (MS11, Oliver 112, page 46)
- Frank Sottile (MS14, Griffin 201, page 58)
- Alex Fedoseyev (MS17, Griffin 304, page 65)
- Susan E. Minkoff (MS21, Oliver 116, page 74)
- Giacomo Micheli (MS22, Griffin 215, page 75)
- Junping Shi (MS23, Oliver 119A, page 79)
- Zhuolin Qu (MS25, Oliver 117, page 85)
- Keon Ho Kim (MS28, Oliver 101, page 94)
- Asim Dey (MS30, Griffin 144, page 98)
- Shane A. McQuarrie (MS33, Griffin 305, page 106)

B2.2: Saturday (11/4) 10:15 am - 10:45 am

- Yonghua Yan (MS01, Griffin 129, page 11)
- Keegan Kirk (MS02, Griffin 301, page 15)
- Daniel Massatt (MS04, Griffin 302, page 24)
- Christina G. Taylor (MS07, Griffin 130, page 33)
- Gabriela Jaramillo (MS11, Oliver 112, page 47)
- Derek Wu (MS14, Griffin 201, page 58)
- Jidong Wang (MS16, Griffin 203, page 62)
- Shreedhar Bhat (MS17, Griffin 304, page 65)
- Alexander Mamonov (MS21, Oliver 116, page 74)
- Felice Manganiello (MS22, Griffin 215, page 75)

B2.3: Saturday (11/4) 10:45 am - 11:15 am

B2.4: Saturday (11/4) 11:15 am - 11:45 am

- Alexey Sukhinin (MS11, Oliver 112, page 47)
- Hang Huang (MS14, Griffin 201, page 59)
- Greg Blekherman (MS16, Griffin 203, page 63)
- John Treuer (MS17, Griffin 304, page 65)
- Kirsten Morris (MS22, Griffin 215, page 76)
- Scott Cook (MS23, Oliver 119A, page 81)
- Summer Atkins (MS25, Oliver 117, page 86)
- Hongfei Chen (MS28, Oliver 101, page 95)
- Henry Adams (MS30, Griffin 144, page 99)
- Tingting Tang (MS32, Griffin 204, page 103)
- Qingguang Guan (MS33, Griffin 305, page 107)

B3: Saturday (11/4) 01:30 pm - 03:30 pm

B3.1: Saturday (11/4) 01:30 pm - 02:00 pm

- Jordan Hoffart (MS02, Griffin 301, page 16)
- Yukun Yue (MS03, Griffin 302, page 18)
- William A. Sands (MS08, Griffin 130, page 35)
- Zehua Lai (MS09, Griffin 204, page 38)
- Shari Moskow (MS10, Oliver 112, page 41)
- Matthew Powell (MS12, Oliver 101, page 48)
- Beatrice Riviere (MS13, Griffin 144, page 52)
- Tai Ha (MS15, Griffin 305, page 59)
- Georgy Scholten (MS16, Griffin 203, page 63)
- Bingyuan Liu (MS17, Griffin 304, page 66)
- Mikhail Mazin (MS18, Griffin 202, page 67)
- Hristo V. Kojouharov (MS24, Oliver 117, page 81)
- Benno Rumpf (MS26, Oliver 116, page 88)
- Shuang Zhang (MS29, Griffin 129, page 95)
- William Ott (MS31, Oliver 119A, page 100)

B3.2: Saturday (11/4) 02:00 pm - 02:30 pm

- Matthias Maier (MS02, Griffin 301, page 17)
- Andrew Hicks (MS03, Griffin 302, page 18)
- Matthew Faust (MS06, Griffin 201, page 30)
- Johannes Krotz (MS08, Griffin 130, page 35)
- C.J. Bott (MS09, Griffin 204, page 38)
- Peijun Li (MS10, Oliver 112, page 41)
- Burak Hatinoglu (MS12, Oliver 101, page 48)
- Haizhao Yang (MS13, Griffin 144, page 52)
- Aleksandra Sobieska (MS15, Griffin 305, page 60)
- Hernan Iriarte (MS16, Griffin 203, page 64)
- Tanuj Gupta (MS17, Griffin 304, page 66)
- Erik Carlsson (MS18, Griffin 202, page 68)
- Sylvia Amihere (MS24, Oliver 117, page 82)
- Benjamin Seeger (MS26, Oliver 116, page 89)
- Lianghao Cao (MS29, Griffin 129, page 96)
- Bhargav Karamched (MS31, Oliver 119A, page 100)

B3.3: Saturday (11/4) 02:30 pm - 03:00 pm

- Madison Sheridan (MS02, Griffin 301, page 17)
- Jiguang Sun (MS03, Griffin 302, page 19)
- Jonah Robinson (MS06, Griffin 201, page 30)
- Yimin Zhong (MS08, Griffin 130, page 35)
- Weixun Deng (MS09, Griffin 204, page 38)
- Taoufik Meklachi (MS10, Oliver 112, page 41)
- Tal Malinovitch (MS12, Oliver 101, page 48)
- Yang Yang (MS13, Griffin 144, page 53)
- Yupeng Li (MS15, Griffin 305, page 60)
- Nate Vaduthala (MS16, Griffin 203, page 64)

- Ilya Kachkovskiy (MS17, Griffin 304, page 66)
- Galen Dorpalen-Barry (MS18, Griffin 202, page 68)
- Hiram H. López (MS22, Griffin 215, page 76)
- Joshua Macdonald (MS24, Oliver 117, page 82)
- Minh Binh Tran (MS26, Oliver 116, page 89)
- Alejandro Diaz (MS29, Griffin 129, page 96)
- Amanda M. Alexander (MS31, Oliver 119A, page 101)

B3.4: Saturday (11/4) 03:00 pm - 03:30 pm

- Zuodong Wang (MS02, Griffin 301, page 17)
- Tommaso Buvoli (MS03, Griffin 302, page 19)
- Jordy Lopez Garcia (MS06, Griffin 201, page 30)
- Juntao Huang (MS08, Griffin 130, page 36)
- Yijun Dong (MS09, Griffin 204, page 39)
- Daniel Onofrei (MS10, Oliver 112, page 42)
- Omar Hurtado (MS12, Oliver 101, page 49)
- Chunmei Wang (MS13, Griffin 144, page 53)
- Naufil Sakran (MS15, Griffin 305, page 60)
- Daniel Corey (MS16, Griffin 203, page 64)
- Matthew Faust (MS17, Griffin 304, page 67)
- Theo Douvropoulos (MS18, Griffin 202, page 68)
- Rodrigo San-José (MS22, Griffin 215, page 77)
- Tamer Oraby (MS24, Oliver 117, page 83)
- Andrei Tarfulea (MS26, Oliver 116, page 89)
- Marco Tezzele (MS29, Griffin 129, page 97)
- Jay Newby (MS31, Oliver 119A, page 101)

B4: Saturday (11/4) 03:45 pm - 04:45 pm, Sunday (11/5) 09:45 am - 10:45 am

B4.1: Saturday (11/4) 03:45 pm - 04:15 pm

- Yang Yang (MS03, Griffin 302, page 19)
- Jie Long (MS05, Griffin 129, page 27)
- Michael DiPasquale (MS06, Griffin 201, page 31)
- Andrés Felipe Galindo-Olarte (MS08, Griffin 130, page 36)
- Bart van Bloemen Waanders (MS10, Oliver 112, page 42)
- Wencai Liu (MS12, Oliver 101, page 49)
- Zheng Sun (MS13, Griffin 144, page 53)
- Ayah Almousa (MS15, Griffin 305, page 61)
- Catherine H. Yan (MS18, Griffin 202, page 69)
- Daniel P. Bossaller (MS22, Griffin 215, page 77)
- Jude Kong (MS34, Oliver 119A, page 108)

B4.2: Saturday (11/4) 04:15 pm - 04:45 pm

- Qingguo Hong (MS03, Griffin 302, page 20)
- Lihan Wang (MS05, Griffin 129, page 27)
- Hal Schenck (MS06, Griffin 201, page 31)
- Kunlun Qi (MS08, Griffin 130, page 37)
- Matthias Chung (MS10, Oliver 112, page 42)
- Frank Sottile (MS12, Oliver 101, page 49)
- Shuhao Cao (MS13, Griffin 144, page 54)
- Nestor Diaz (MS15, Griffin 305, page 61)
- Garrett Nelson (MS18, Griffin 202, page 69)
- Indalecio Ruiz Bolanos (MS22, Griffin 215, page 77)
- Keng Deng (MS34, Oliver 119A, page 108)

B4.3: Sunday (11/5) 09:45 am - 10:15 am

- Yerbol Palzhanov (MS03, Griffin 302, page 20)
- Chenyu Tian (MS05, Griffin 129, page 28)
- Chen Liu (MS08, Griffin 130, page 37)
- Amit N Subrahmanya (MS10, Oliver 112, page 43)
- Xiaowen Zhu (MS12, Oliver 101, page 50)
- Andrés Felipe Galindo-Olarte (MS13, Griffin 144, page 54)
- Mahir Can (MS15, Griffin 305, page 61)
- Nathan Williams (MS18, Griffin 202, page 69)
- Ryann Cartor (MS22, Griffin 215, page 78)
- Saber Elaydi (MS34, Oliver 119A, page 108)

B4.4: Sunday (11/5) 10:15 am - 10:45 am

- Carlos Nicolas Rautenberg (MS03, Griffin 302, page 20)
- Shuhao Cao (MS05, Griffin 129, page 28)
- Zheng Sun (MS08, Griffin 130, page 37)
- Zheyu Wen (MS10, Oliver 112, page 43)
- Iris Emilsdottir (MS12, Oliver 101, page 50)
- Lander Besabe (MS13, Griffin 144, page 55)
- Corey Wolfe (MS15, Griffin 305, page 62)
- Weston Miller (MS18, Griffin 202, page 70)
- Shi Bai (MS22, Griffin 215, page 78)
- Nusrat Tabassum (MS34, Oliver 119A, page 109)

B5: Sunday (11/5) 11:00 am - 01:00 pm

B5.1: Sunday (11/5) 11:00 am - 11:30 am

- Shawn W. Walker (MS03, Griffin 302, page 21)
- Bryant Wyatt (MS05, Griffin 129, page 28)

- Joshua Goldstein (MS09, Griffin 204, page 39)
- Tan Bui-Thanh (MS10, Oliver 112, page 43)
- Stephen P. Shipman (MS12, Oliver 101, page 50)
- Yuan Liu (MS13, Griffin 144, page 55)
- Hana Dobrovolny (MS19, Oliver 117, page 70)
- Lisa M. Kuhn (MS20, Griffin 130, page 72)
- Seungki Kim (MS22, Griffin 215, page 78)
- Narendra Pant (MS34, Oliver 119A, page 109)

B5.2: Sunday (11/5) 11:30 am - 12:00 pm

- Alan Demlow (MS03, Griffin 302, page 21)
- Mohammad Mahabubur Rahman (MS05, Griffin 129, page 29)
- Yifan Zhang (MS09, Griffin 204, page 40)
- Mikhail Zaslavsky (MS10, Oliver 112, page 44)
- Jordy Lopez Garcia (MS12, Oliver 101, page 51)
- Joseph Hunter (MS13, Griffin 144, page 55)
- Manar Alkuzweny (MS19, Oliver 117, page 71)
- Justin Biggs (MS20, Griffin 130, page 72)
- Aria Nosratinia (MS22, Griffin 215, page 79)
- Mohammad Mihrab Uddin Chowdhury (MS34, Oliver 119A, page 110)

B5.3: Sunday (11/5) 12:00 pm - 12:30 pm

- Paul Schwering (MS03, Griffin 302, page 21)
- Rui Zhang (MS05, Griffin 129, page 29)
- Elzbieta Polak (MS09, Griffin 204, page 40)
- Vladimir Druskin (MS10, Oliver 112, page 44)
- Marshall King (MS12, Oliver 101, page 51)
- Peimeng Yin (MS13, Griffin 144, page 56)
- Saburi Rasheed (MS19, Oliver 117, page 71)
- Jacob Boyt (MS20, Griffin 130, page 73)
- Ananth Vedururu Srinivas (MS34, Oliver 119A, page 110)

B5.4: Sunday (11/5) 12:30 pm - 01:00 pm

- Jeonghun J. Lee (MS03, Griffin 302, page 22)
- Georgy Scholten (MS09, Griffin 204, page 40)
- Jinpu Zhou (MS10, Oliver 112, page 44)
- Yuliia Yershova (MS12, Oliver 101, page 51)
- Nanyi Zheng (MS13, Griffin 144, page 56)
- Quiyana M. Murphy (MS19, Oliver 117, page 72)
- Jenita Jahangir (MS34, Oliver 119A, page 111)

List of Mini-Symposium Presenters

- Henry Adams (MS30, Griffin 144, page 99)

  Time: Saturday (11/4) 11:15 am - 11:45 am

  Title: Hausdorff vs Gromov-Hausdorff distances

  Affiliation: University of Florida

- Jimmie Adriazola (MS11, Oliver 112, page 45)

  Time: Friday (11/3) 03:00 pm - 03:30 pm

  Title: Optimal Control of Branched Flow

  Affiliation: Southern Methodist University

- Nazia Afrin (MS25, Oliver 117, page 86)

  Time: Saturday (11/4) 10:15 am - 10:45 am

  Title: Bistability in models of Hepatitis B virus dynamics

  Affiliation: University of Louisiana at Lafayette

- Abeer Al Ahmadieh (MS14, Griffin 201, page 57)

  Time: Friday (11/3) 03:30 pm - 04:00 pm

  Title: The principal minor map

  Affiliation: Georgia Institute of Technology

- Amanda M. Alexander (MS31, Oliver 119A, page 101)

  Time: Saturday (11/4) 02:30 pm - 03:00 pm

  Title: A Subdiffusive Analysis of Transcription Factor Binding Kinetics

  Affiliation: University of Houston

- Manar Alkuzweny (MS19, Oliver 117, page 71)

  Time: Sunday (11/5) 11:30 am - 12:00 pm

  Title: Characterizing a novel dengue vaccine by leveraging clinical trial data with a multi-level model

  Affiliation: University of Notre Dame, Department of Biological Sciences

- Ayah Almousa (MS15, Griffin 305, page 61)

  Time: Saturday (11/4) 03:45 pm - 04:15 pm

  Title: Alexander Duals of Symmetric Simplicial Complexes and Stanley-Reisner Ideals

  Affiliation: University of Minnesota

- Safeyya Alyahia (MS27, Griffin 203, page 91)

  Time: Friday (11/3) 03:30 pm - 04:00 pm

  Title: Dynamic Event-Triggered Control of Linear Continuous-Time Systems

  Affiliation: Louisiana State University

- Sylvia Amihere (MS24, Oliver 117, page 82)

  Time: Saturday (11/4) 02:00 pm - 02:30 pm

  Title: Benchmarking Electrostatic Free Energy of the Nonlinear Poisson-Boltzmann Model for the Kirkwood Sphere

  Affiliation: University of Alabama

- Nicole Aretz (MS33, Griffin 305, page 104)

  Time: Friday (11/3) 03:30 pm - 04:00 pm

  Title: Exploiting Structure via Nested Operator Inference in Physics-Based Learning

  Affiliation: The University of Texas at Austin

- Summer Atkins (MS25, Oliver 117, page 86)

  Time: Saturday (11/4) 11:15 am - 11:45 am

  Title: An Immuno-epidemiological Model of Foot-and-Mouth Disease in African Buffalo

  Affiliation: Louisiana State University, Department of Mathematics

- Jacob Badger (MS04, Griffin 302, page 24)

  Time: Saturday (11/4) 10:45 am - 11:15 am

  Title: Scalable DPG Multigrid Solver for High-Frequency Helmholtz Problems

  Affiliation: University of Texas at Austin

- Shi Bai (MS22, Griffin 215, page 78)

  Time: Sunday (11/5) 10:15 am - 10:45 am

  Title: Concrete hardness in lattice-based cryptography

  Affiliation: Florida Atlantic University

- Neerob Basak (MS34, Oliver 119A, page 109)

  Time: Sunday (11/5) 11:00 am - 11:30 am

  Title: The dynamics of a discrete-time predator-prey model with predator evolution and periodic prey reproduction

  Affiliation: University of Louisiana at Lafayette

- Allison Beemer (MS22, Griffin 215, page 76)

  Time: Saturday (11/4) 10:45 am - 11:15 am

  Title: Transforming Adversarial MACs to Erasure Channels for Partial Correction

  Affiliation: University of Wisconsin-Eau Claire

- Lander Besabe (MS13, Griffin 144, page 55)

  Time: Sunday (11/5) 10:15 am - 10:45 am

  Title: Large Eddy Simulation for the quasi-geostrophic equations

  Affiliation: University of Houston

- Manaswinee Bezbaruah (MS04, Griffin 302, page 25)

  Time: Saturday (11/4) 11:15 am - 11:45 am

  Title: Shape optimization of optical microscale inclusions

  Affiliation: Texas A&M University

- Shreedhar Bhat (MS17, Griffin 304, page 65)

  Time: Saturday (11/4) 10:15 am - 10:45 am

  Title: p-Skwarczyński distance

  Affiliation: Texas A&M University

- Suparno Bhattacharyya (MS33, Griffin 305, page 104)

  Time: Friday (11/3) 04:00 pm - 04:30 pm

  Title: Role of Hyper-Reduction in Enhancing the Efficacy of Digital Twins

  Affiliation: Texas A&M University

- Christin Bibby (MS16, Griffin 203, page 63)

  Time: Saturday (11/4) 10:45 am - 11:15 am

  Title: From configurations on graphs to moduli spaces of (tropical) curves

  Affiliation: LSU

- Justin Biggs (MS20, Griffin 130, page 72)

  Time: Sunday (11/5) 11:30 am - 12:00 pm

  Title: Challenges with simulating multiple component beam structures with linear control design

  Affiliation: Louisiana Tech University

- Greg Blekherman (MS16, Griffin 203, page 63)

  Time: Saturday (11/4) 11:15 am - 11:45 am

  Title: Tropicalization in Extremal Combinatorics

  Affiliation: Georgia Tech

- Paul Blochas (MS26, Oliver 116, page 88)

  Time: Friday (11/3) 04:00 pm - 04:30 pm

  Title: Uniform Asymptotic Stability for Convection-Reaction-Diffusion Equations in the Inviscid Limit Towards Riemann Shocks

  Affiliation: University of Texas at Austin

- Indalecio Ruiz Bolanos (MS22, Griffin 215, page 77)

  Time: Saturday (11/4) 04:15 pm - 04:45 pm

  Title: Nonlinear Reed Solomon codes

  Affiliation: Baylor University

- Daniel P. Bossaller (MS22, Griffin 215, page 77)

  Time: Saturday (11/4) 03:45 pm - 04:15 pm

  Title: List Decoding of Skew Reed-Solomon Codes

  Affiliation: University of Alabama in Huntsville

- C.J. Bott (MS09, Griffin 204, page 38)

  Time: Saturday (11/4) 02:00 pm - 02:30 pm

  Title: SchubertIdeals.m2: A Software Package for the Schubert Calculus of Flag Varieties

  Affiliation: Texas A&M University

- Jacob Boyt (MS20, Griffin 130, page 73)

  Time: Sunday (11/5) 12:00 pm - 12:30 pm

  Title: Neural network method for solving parabolic two-temperature micro/nanoscale heat conduction in double-layered thin films exposed to ultrashort-pulsed lasers

  Affiliation: Louisiana Tech University

- Cameron Browne (MS25, Oliver 117, page 85)

  Time: Friday (11/3) 04:30 pm - 05:00 pm

  Title: Connecting the evolutionary genetics of HIV to prey-predator dynamics with immune response

  Affiliation: University of Louisiana at Lafayette

- Tan Bui-Thanh (MS10, Oliver 112, page 43)

  Time: Sunday (11/5) 11:00 am - 11:30 am

  Title: Model-constrained uncertainty quantification for scientific deep learning of inverse solutions

  Affiliation: The University of Texas at Austin

- Tommaso Buvoli (MS03, Griffin 302, page 19)

  Time: Saturday (11/4) 03:00 pm - 03:30 pm

  Title: Exponential Integrators and the Polynomial Time Integration Framework

  Affiliation: Tulane University

- Mahir Can (MS15, Griffin 305, page 61)

  Time: Sunday (11/5) 09:45 am - 10:15 am

  Title: K-orbit closures and Hessenberg varieties

  Affiliation: Tulane University

- Jonathan Cangelosi (MS33, Griffin 305, page 103)

  Time: Friday (11/3) 03:00 pm - 03:30 pm

  Title: Adaptive Gaussian Process Modeling for Trajectory Optimization with Model Inexactness

  Affiliation: Rice University

- Lianghao Cao (MS29, Griffin 129, page 96)
  Time: Saturday (11/4) 02:00 pm - 02:30 pm
  Title: Efficient geometric MCMC enabled by neural operators with parametric derivative training
  Affiliation: The University of Texas at Austin
- Shuhao Cao (MS05, Griffin 129, page 28)
  Time: Sunday (11/5) 10:15 am - 10:45 am
  Title: Immersed Virtual Element Methods for H(curl) Interface Problems in Three Dimensions
  Affiliation: UMKC
- Shuhao Cao (MS13, Griffin 144, page 54)
  Time: Saturday (11/4) 04:15 pm - 04:45 pm
  Title: Noise-robust Deep Direct Sampling via Transformers
  Affiliation: UMKC
- Loic Cappanera (MS07, Griffin 130, page 32)
  Time: Friday (11/3) 04:00 pm - 04:30 pm
  Title: Towards high order methods for incompressible Navier-Stokes equations with variable density
  Affiliation: University of Houston
- Erik Carlsson (MS18, Griffin 202, page 68)
  Time: Saturday (11/4) 02:00 pm - 02:30 pm
  Title: Descents polynomial and parking functions
  Affiliation: University of California, Davis
- Ryann Cartor (MS22, Griffin 215, page 78)
  Time: Sunday (11/5) 09:45 am - 10:15 am
  Title: Total Break of a Public Key Cryptosystem Based on a Group of Permutation Polynomials
  Affiliation: Clemson University
- Adrian Celaya (MS28, Oliver 101, page 93)
  Time: Friday (11/3) 04:30 pm - 05:00 pm
  Title: Multigrid Inspired Deep Learning Architectures for Medical Imaging Segmentation
  Affiliation: Rice University
- Ankit Chakraborty (MS07, Griffin 130, page 34)
  Time: Saturday (11/4) 11:15 am - 11:45 am
  Title: An Anisotropic *hp*-mesh Adaptation Framework for Ultraweak DPG Formulations
  Affiliation: University of Texas at Austin

- Jesse Chan (MS07, Griffin 130, page 33)

  Time: Saturday (11/4) 09:45 am - 10:15 am

  Title: High order entropy stable schemes for the quasi-one-dimensional shallow water and compressible Euler equations

  Affiliation: Rice University

- Chia-Yu Chang (MS14, Griffin 201, page 57)

  Time: Friday (11/3) 04:00 pm - 04:30 pm

  Title: Maximal Border Subrank Tensors

  Affiliation: Texas A&M University

- Hongfei Chen (MS28, Oliver 101, page 95)

  Time: Saturday (11/4) 11:15 am - 11:45 am

  Title: Hydrodynamic Strategies in Choanoflagellate Colonies: A Reduced Model Approach

  Affiliation: Tulane University

- Mohammad Mihrab Uddin Chowdhury (MS34, Oliver 119A, page 110)

  Time: Sunday (11/5) 11:30 am - 12:00 pm

  Title: Amphibian Fungal Pathogen: Unravelling the BSal Epidemic Across the Life Stages of Salamanders

  Affiliation: Texas Tech University

- Matthias Chung (MS10, Oliver 112, page 42)

  Time: Saturday (11/4) 04:15 pm - 04:45 pm

  Title: Big Data Inverse Problems – Promoting Sparsity and Learning to Regularize

  Affiliation: Emory University

- Scott Cook (MS23, Oliver 119A, page 81)

  Time: Saturday (11/4) 11:15 am - 11:45 am

  Title: Neural Network-Based Amortized Bayesian Inference Methods for Parameter Estimation in ODE Epidemic Models

  Affiliation: Tarleton State University

- Daniel Corey (MS16, Griffin 203, page 64)

  Time: Saturday (11/4) 03:00 pm - 03:30 pm

  Title: Singular matroid realization spaces

  Affiliation: University of Nevada, Las Vegas

- Davood Damircheli (MS07, Griffin 130, page 32)

  Time: Friday (11/3) 03:30 pm - 04:00 pm

  Title: Exploring Financial Derivatives through the Lens of the DPG Approach: A Study on Option Pricing and Sensitivity Analysis

  Affiliation: Louisiana State University

- Alan Demlow (MS03, Griffin 302, page 21)

  Time: Sunday (11/5) 11:30 am - 12:00 pm

  Title: Nodal finite element methods for the surface Stokes problem

  Affiliation: Texas A&M University

- Keng Deng (MS34, Oliver 119A, page 108)

  Time: Saturday (11/4) 04:15 pm - 04:45 pm

  Title: Asymptotic profiles of the steady state for a diffusive SIS epidemic model with Dirichlet boundary conditions

  Affiliation: University of Louisiana at Lafayette

- Weixun Deng (MS09, Griffin 204, page 38)

  Time: Saturday (11/4) 02:30 pm - 03:00 pm

  Title: Computing isotopy type of positive zero sets faster for n-variate $(n+k)$-nomials

  Affiliation: Texas A&M University

- Asim Dey (MS30, Griffin 144, page 98)

  Time: Saturday (11/4) 09:45 am - 10:15 am

  Title: Survival Analysis for Topological Data Analysis Features

  Affiliation: University of Texas El Paso

- Papri Dey (MS14, Griffin 201, page 59)

  Time: Saturday (11/4) 10:45 am - 11:15 am

  Title: Combinatorial Aspects of Polynomials with Lorentzian Signature

  Affiliation: Georgia Institute of Technology

- Michael DiPasquale (MS06, Griffin 201, page 31)

  Time: Saturday (11/4) 03:45 pm - 04:15 pm

  Title: Lex-segment initial ideals and the dimension of planar splines

  Affiliation: New Mexico State University

- Alejandro Diaz (MS29, Griffin 129, page 96)

  Time: Saturday (11/4) 02:30 pm - 03:00 pm

  Title: Nonlinear manifold reduced order models with domain decomposition

  Affiliation: Rice University

- Nestor Diaz (MS15, Griffin 305, page 61)

  Time: Saturday (11/4) 04:15 pm - 04:45 pm

  Title: Shellability of symmetric spaces and Bruhat orders

  Affiliation: Tulane University

- Hana Dobrovolny (MS19, Oliver 117, page 70)

  Time: Sunday (11/5) 11:00 am - 11:30 am

  Title: Dynamics of polyaneuploid cancer cell quiescence under stress

  Affiliation: Texas Christian University

- Yijun Dong (MS09, Griffin 204, page 39)

  Time: Saturday (11/4) 03:00 pm - 03:30 pm

  Title: Efficient Bounds and Estimates for Canonical Angles in Randomized Subspace Approximations

  Affiliation: University of Texas at Austin

- Galen Dorpalen-Barry (MS18, Griffin 202, page 68)

  Time: Saturday (11/4) 02:30 pm - 03:00 pm

  Title: Intersection Posets and Weyl Cones of Shi Arrangements

  Affiliation: University of Oregon

- Theo Douvropoulos (MS18, Griffin 202, page 68)

  Time: Saturday (11/4) 03:00 pm - 03:30 pm

  Title: Decompositions of parking spaces and reflection Laplacians

  Affiliation: Brandeis University

- Vladimir Druskin (MS10, Oliver 112, page 44)

  Time: Sunday (11/5) 12:00 pm - 12:30 pm

  Title: Monotonically converging two-sided computable bounds for exponential matrix moments via Lanczos algorithm

  Affiliation: Worcester Polytechnic Institute

- Saber Elaydi (MS34, Oliver 119A, page 108)

  Time: Sunday (11/5) 09:45 am - 10:15 am

  Title: Global Dynamics of Discrete Mathematical Models of Tuberculosis

  Affiliation: Trinity University

- Iris Emilsdottir (MS12, Oliver 101, page 50)

  Time: Sunday (11/5) 10:15 am - 10:45 am

  Title: Johnson-Schwartzman gap labelling and applications

  Affiliation: Rice University

- Matthew Faust (MS06, Griffin 201, page 30)

  Time: Saturday (11/4) 02:00 pm - 02:30 pm

  Title: Critical Points of Discrete Periodic Operators

  Affiliation: Texas A&M University

- Matthew Faust (MS17, Griffin 304, page 67)

  Time: Saturday (11/4) 03:00 pm - 03:30 pm

  Title: On Irreducibility of the Bloch variety

  Affiliation: Texas A&M University

- Alex Fedoseyev (MS01, Griffin 129, page 12)

  Time: Saturday (11/4) 11:15 am - 11:45 am

  Title: Simulation of Rarefied Hypersonic Gas Flow Using Alexeev Generalized Hydrodynamic Equations

  Affiliation: Ultra Quantum Inc., Huntsville, Alabama, USA

- Alex Fedoseyev (MS17, Griffin 304, page 65)

  Time: Saturday (11/4) 09:45 am - 10:15 am

  Title: Alexeev Generalized Hydrodynamic Equations for Turbulent Flows

  Affiliation: Ultra Quantum Inc., Huntsville, Alabama, USA

- Shreyas Sunil Gaikwad (MS33, Griffin 305, page 105)

  Time: Friday (11/3) 04:30 pm - 05:00 pm

  Title: Can eXplainable-AI (XAI) Capture Robust Dynamical Relationships in Ice and Ocean Modeling?

  Affiliation: University of Texas at Austin

- Andrés Felipe Galindo-Olarte (MS08, Griffin 130, page 36)

  Time: Saturday (11/4) 03:45 pm - 04:15 pm

  Title: Superconvergence and accuracy enhancement of discontinuous Galerkin solutions for Vlasov-Maxwell equations

  Affiliation: University of Texas at Austin - ODEN institute

- Andrés Felipe Galindo-Olarte (MS13, Griffin 144, page 54)

  Time: Sunday (11/5) 09:45 am - 10:15 am

  Title: Numerical analysis of a hybrid method for radiation transport

  Affiliation: University of Texas at Austin/ODEN institute

- Jordy Lopez Garcia (MS06, Griffin 201, page 30)

  Time: Saturday (11/4) 03:00 pm - 03:30 pm

  Title: $\mathbb{A}^1$-Brouwer Degrees in Macaulay2

  Affiliation: Texas A&M University

- Jordy Lopez Garcia (MS12, Oliver 101, page 51)

  Time: Sunday (11/5) 11:30 am - 12:00 pm

  Title: Operators, Polytopes and Toric Geometry

  Affiliation: Texas A&M University

- Seth Gerberding (MS04, Griffin 302, page 23)
  Time: Friday (11/3) 04:30 pm - 05:00 pm
  Title: High-order approximation of dispersive PDEs
  Affiliation: Texas A&M University
- Anna Ghazaryan (MS11, Oliver 112, page 46)
  Time: Saturday (11/4) 09:45 am - 10:15 am
  Title: Stability of fronts in the diffusive Rosenzweig - MacArthur Model
  Affiliation: Miami University
- Joshua Goldstein (MS09, Griffin 204, page 39)
  Time: Sunday (11/5) 11:00 am - 11:30 am
  Title: Near-optimal bounds for the number of p-adic roots of circuit systems
  Affiliation: Texas A&M
- Qingguang Guan (MS33, Griffin 305, page 107)
  Time: Saturday (11/4) 11:15 am - 11:45 am
  Title: Modeling the Open Probability of Ion Channels on Cell/Organelle Membranes using Deep Neural Networks
  Affiliation: University of Southern Mississippi
- Jean-Luc Guermond (MS02, Griffin 301, page 16)
  Time: Saturday (11/4) 10:45 am - 11:15 am
  Title: Invariant-domain preserving and involution preserving IMEX schemes for magneto-hydrodynamics
  Affiliation: Department of Mathematics, Texas A&M University, College Station, TX 77843
- Hayriye Gulbudak (MS25, Oliver 117, page 83)
  Time: Friday (11/3) 03:00 pm - 03:30 pm
  Title: Sensitivity Analysis in an Immuno-Epidemiological Vector-Host Model
  Affiliation: University of Louisiana at Lafayette
- Wei Guo (MS02, Griffin 301, page 15)
  Time: Saturday (11/4) 09:45 am - 10:15 am
  Title: A learned conservative semi-Lagrangian finite volume scheme for transport simulations
  Affiliation: Texas Tech University
- Tanuj Gupta (MS17, Griffin 304, page 66)
  Time: Saturday (11/4) 02:00 pm - 02:30 pm
  Title: Modifications of the Levi Core
  Affiliation: Texas A&M University, College Station

- Tai Ha (MS15, Griffin 305, page 59)
  Time: Saturday (11/4) 01:30 pm - 02:00 pm
  Title: Scarf complexes of graphs and their powers
  Affiliation: Tulane University
- Thomas Hagstrom (MS26, Oliver 116, page 87)
  Time: Friday (11/3) 03:00 pm - 03:30 pm
  Title: Direct Computation of Singular Solutions for Fluid Models
  Affiliation: Southern Methodist University
- Qi Han (MS17, Griffin 304, page 65)
  Time: Saturday (11/4) 10:45 am - 11:15 am
  Title: On partial differential equations of Waring's-problem form in several complex variables
  Affiliation: Texas A&M University-San Antonio
- Burak Hatinoglu (MS12, Oliver 101, page 48)
  Time: Saturday (11/4) 02:00 pm - 02:30 pm
  Title: Logarithmic Capacities of Rational Frequency Approximants for Almost Mathieu Operator
  Affiliation: Michigan State University
- Yunhui He (MS05, Griffin 129, page 26)
  Time: Friday (11/3) 04:00 pm - 04:30 pm
  Title: Some theoretical results on finite convergence property of Anderson acceleration on linear systems
  Affiliation: University of Houston
- Andrew Hicks (MS03, Griffin 302, page 18)
  Time: Saturday (11/4) 02:00 pm - 02:30 pm
  Title: Modeling and Numerical Analysis of the Cholesteric Landau–de Gennes model
  Affiliation: Louisiana State University
- Jordan Hoffart (MS02, Griffin 301, page 16)
  Time: Saturday (11/4) 01:30 pm - 02:00 pm
  Title: Towards an involution-preserving solver for the time-dependent Maxwell equations
  Affiliation: Texas A&M University
- Qingguo Hong (MS03, Griffin 302, page 20)
  Time: Saturday (11/4) 04:15 pm - 04:45 pm
  Title: A New Practical Framework for the Stability Analysis of Perturbed Saddle-point Problems and Applications
  Affiliation: Missouri S&T

- Mahmudul Bari Hridoy (MS32, Griffin 204, page 102)

  Time: Saturday (11/4) 10:45 am - 11:15 am

  Title: Investigating Patterns of Disease Emergence in Stochastic Epidemic Models with Seasonality

  Affiliation: Department of Mathematics and Statistics, Texas Tech University

- Hang Huang (MS14, Griffin 201, page 59)

  Time: Saturday (11/4) 11:15 am - 11:45 am

  Title: Betti Tables of the 2×2 permanents of a $2 \times n$ matrix

  Affiliation: Auburn University

- Juntao Huang (MS02, Griffin 301, page 14)

  Time: Friday (11/3) 04:00 pm - 04:30 pm

  Title: Positivity-preserving time discretizations for production-destruction equations with applications to non-equilibrium flows

  Affiliation: Texas Tech University

- Juntao Huang (MS08, Griffin 130, page 36)

  Time: Saturday (11/4) 03:00 pm - 03:30 pm

  Title: Hyperbolic machine learning moment closure models for the radiative transfer equation

  Affiliation: Texas Tech University

- Joseph Hunter (MS13, Griffin 144, page 55)

  Time: Sunday (11/5) 11:30 am - 12:00 pm

  Title: Realizability-Preserving DG-IMEX Method for a Two-Moment Model of Special Relativistic Transport

  Affiliation: Ohio State University

- Omar Hurtado (MS12, Oliver 101, page 49)

  Time: Saturday (11/4) 03:00 pm - 03:30 pm

  Title: Unique continuation, Wegner lemma, and localization for non-stationary random Schrödinger operators on $\mathbb{Z}^2$

  Affiliation: University of California, Irvine

- Hernan Iriarte (MS16, Griffin 203, page 64)

  Time: Saturday (11/4) 02:00 pm - 02:30 pm

  Title: Higher rank tropical geometry and the variation of the demand

  Affiliation: UT Austin

- Olaniyi Samuel Iyiola (MS05, Griffin 129, page 27)

  Time: Friday (11/3) 04:30 pm - 05:00 pm

  Title: Double Inertial Iterative Schemes and Dynamical System

  Affiliation: Morgan State University

- Jenita Jahangir (MS34, Oliver 119A, page 111)

  Time: Sunday (11/5) 12:30 pm - 01:00 pm

  Title: A Discrete-time stage-structured host-parasitoid model with combinations of various pest control strategies

  Affiliation: University of Louisiana at Lafayette

- Gabriela Jaramillo (MS11, Oliver 112, page 47)

  Time: Saturday (11/4) 10:15 am - 10:45 am

  Title: Patterns in Oscillatory Media with Nonlocal Coupling

  Affiliation: University of Houston

- Mat Johnson (MS11, Oliver 112, page 46)

  Time: Friday (11/3) 04:30 pm - 05:00 pm

  Title: Subharmonic Stability of Periodic Traveling Waves in Dissipative Systems

  Affiliation: The University of Kansas

- Raven Shane Johnson (MS28, Oliver 101, page 94)

  Time: Saturday (11/4) 10:15 am - 10:45 am

  Title: A Pseudo-differential Sweeping Method for the Helmholtz Equation

  Affiliation: Rice University

- Tiffany Frugé Jones (MS05, Griffin 129, page 26)

  Time: Friday (11/3) 03:00 pm - 03:30 pm

  Title: Expressibility of the Global Difference of Exponential Splitting Approximations

  Affiliation: Sam Houston State University, Huntsville, TX

- Robert Viator Jr. (MS04, Griffin 302, page 23)

  Time: Friday (11/3) 03:30 pm - 04:00 pm

  Title: Bloch Waves for Maxwell's Equations in High-Contrast Photonic Crystals

  Affiliation: Denison University

- Ilya Kachkovskiy (MS17, Griffin 304, page 66)

  Time: Saturday (11/4) 02:30 pm - 03:00 pm

  Title: Arithmetic phase transitions for one-dimensional quasiperiodic operators with monotone potentials

  Affiliation: Michigan State University

- Bhargav Karamched (MS31, Oliver 119A, page 100)

  Time: Saturday (11/4) 02:00 pm - 02:30 pm

  Title: Stochastic Switching of Delayed Feedback Suppresses Oscillations in Genetic Regulatory Systems

  Affiliation: Florida State University

- Joe Kileel (MS14, Griffin 201, page 58)

  Time: Friday (11/3) 04:30 pm - 05:00 pm

  Title: Moment Estimation of Nonparametric Mixtures Through Implicit Tensor Decomposition

  Affiliation: University of Texas at Austin

- Keon Ho Kim (MS28, Oliver 101, page 94)

  Time: Saturday (11/4) 09:45 am - 10:15 am

  Title: An immersed peridynamics method for fluid-driven material damage and failure

  Affiliation: Oden institute for Computational Engineering and Sciences, University of Texas at Austin

- Seungki Kim (MS22, Griffin 215, page 78)

  Time: Sunday (11/5) 11:00 am - 11:30 am

  Title: A physical study of the LLL algorithm

  Affiliation: University of Cincinnati

- Marshall King (MS12, Oliver 101, page 51)

  Time: Sunday (11/5) 12:00 pm - 12:30 pm

  Title: Exotic Eigenvalues for Quantum Graphs with Shrinking Edges

  Affiliation: Texas A&M University

- Keegan Kirk (MS02, Griffin 301, page 15)

  Time: Saturday (11/4) 10:15 am - 10:45 am

  Title: Convergence of a pressure-robust space-time hybridized discontinuous Galerkin method for incompressible flows

  Affiliation: Rice University

- Jackson Knox (MS27, Griffin 203, page 91)

  Time: Friday (11/3) 04:00 pm - 04:30 pm

  Title: A Discrete-Time Trajectory-Based Stabilization Approach

  Affiliation: Louisiana State University

- Hristo V. Kojouharov (MS24, Oliver 117, page 81)

  Time: Saturday (11/4) 01:30 pm - 02:00 pm

  Title: Modeling of biological systems using higher-order modified nonstandard finite difference methods for autonomous dynamical systems

  Affiliation: University of Texas at Arlington

- Jude Kong (MS34, Oliver 119A, page 108)

  Time: Saturday (11/4) 03:45 pm - 04:15 pm

  Title: Phytoplankton competition for nutrients and light in a stratified lake: A mathematical model connecting epilimnion and hypolimnion

  Affiliation: York University

- Johannes Krotz (MS08, Griffin 130, page 35)
  Time: Saturday (11/4) 02:00 pm - 02:30 pm
  Title: A Hybrid Monte Carlo, Discontinuous Galerkin method for linear kinetic transport equations
  Affiliation: University of Tennessee Knoxville
- Lisa M. Kuhn (MS20, Griffin 130, page 72)
  Time: Sunday (11/5) 11:00 am - 11:30 am
  Title: Numerical studies of finite element solutions to one and two-dimensional structures
  Affiliation: Southeastern Louisiana University
- Hiram H. López (MS22, Griffin 215, page 76)
  Time: Saturday (11/4) 02:30 pm - 03:00 pm
  Title: Monomial norm-trace codes
  Affiliation: Virginia Tech
- Zehua Lai (MS09, Griffin 204, page 38)
  Time: Saturday (11/4) 01:30 pm - 02:00 pm
  Title: Tensor products of reproducing kernel Banach spaces
  Affiliation: University of Texas at Austin
- J.M. Landsberg (MS14, Griffin 201, page 57)
  Time: Friday (11/3) 03:00 pm - 03:30 pm
  Title: Geometry and the complexity of matrix multiplication: recent developments
  Affiliation: Texas A&M University
- Leah LeJeune (MS25, Oliver 117, page 84)
  Time: Friday (11/3) 03:30 pm - 04:00 pm
  Title: Mathematical formulations for representing human risk response in epidemic models
  Affiliation: Virginia Tech
- Jeonghun J. Lee (MS03, Griffin 302, page 22)
  Time: Sunday (11/5) 12:30 pm - 01:00 pm
  Title: Hybridizable discontinuous Galerkin methods for coupled systems of porous/poroelastic media and free flow equations
  Affiliation: Baylor University
- Jiaqi Li (MS07, Griffin 130, page 33)
  Time: Friday (11/3) 04:30 pm - 05:00 pm
  Title: A DPG method for the full-potential equation
  Affiliation: University of Texas at Austin

- Peijun Li (MS10, Oliver 112, page 41)

  Time: Saturday (11/4) 02:00 pm - 02:30 pm

  Title: A data-assisted two-stage method for the inverse random source problem

  Affiliation: Purdue University

- Wenwen Li (MS30, Griffin 144, page 99)

  Time: Saturday (11/4) 10:45 am - 11:15 am

  Title: Configuration Spaces of Metric Graphs with Restraint Parameters

  Affiliation: Hobart and William Smith Colleges

- Yupeng Li (MS15, Griffin 305, page 60)

  Time: Saturday (11/4) 02:30 pm - 03:00 pm

  Title: Minimal resolutions of lattice ideals

  Affiliation: Duke University

- Junshan Lin (MS04, Griffin 302, page 24)

  Time: Saturday (11/4) 09:45 am - 10:15 am

  Title: Edge modes in several topological wave insulators

  Affiliation: Auburn University

- Yimin Lin (MS02, Griffin 301, page 13)

  Time: Friday (11/3) 03:30 pm - 04:00 pm

  Title: Limiting techniques for high order, entropy stable, and positivity-preserving discontinuous Galerkin discretizations

  Affiliation: Rice University

- Bingyuan Liu (MS17, Griffin 304, page 66)

  Time: Saturday (11/4) 01:30 pm - 02:00 pm

  Title: The Diederich–Fornæss index and the $\bar{\partial}$-Neumann problem

  Affiliation: The University of Texas Rio Grande Valley

- Chen Liu (MS08, Griffin 130, page 37)

  Time: Sunday (11/5) 09:45 am - 10:15 am

  Title: An Efficient Nonsmooth Convex Optimization-based High-order Accurate Bound-preserving Limiter for time-dependent Problems

  Affiliation: Purdue University

- Rongsong Liu (MS23, Oliver 119A, page 80)

  Time: Saturday (11/4) 10:15 am - 10:45 am

  Title: Mathematical modeling of population structure in bioreactors seeded with light-controllable microbial stem cells

  Affiliation: University of Wyoming

- Wencai Liu (MS12, Oliver 101, page 49)

  Time: Saturday (11/4) 03:45 pm - 04:15 pm

  Title: Geometric Borg's Theorem in arbitrary dimensions

  Affiliation: Texas A&M University

- Yuan Liu (MS13, Griffin 144, page 55)

  Time: Sunday (11/5) 11:00 am - 11:30 am

  Title: Discontinuous Galerkin methods for network patterning phase-field models

  Affiliation: Wichita State University

- Jie Long (MS05, Griffin 129, page 27)

  Time: Saturday (11/4) 03:45 pm - 04:15 pm

  Title: Sparse Data Regulation on GRUs Neural Network for Solving Time-Dependent PDEs

  Affiliation: Middle Tennessee State University

- Pavel Lushnikov (MS26, Oliver 116, page 87)

  Time: Friday (11/3) 03:30 pm - 04:00 pm

  Title: Conformal mappings, computation of dynamics on various Riemann surface sheets and integrability of surface dynamics

  Affiliation: University of New Mexico

- Joshua Macdonald (MS24, Oliver 117, page 82)

  Time: Saturday (11/4) 02:30 pm - 03:00 pm

  Title: Within-host viral growth and immune response rates predict FMDV transmission dynamics for African Buffalo

  Affiliation: School of Zoology, Goerge S. Wise Faculty of Life Sciences, Tel Aviv University

- Joshua Macdonald (MS25, Oliver 117, page 84)

  Time: Friday (11/3) 04:00 pm - 04:30 pm

  Title: Robust parameterization of a viral-immune kinetics model for sequential Dengue virus (DEN-V) infections with Antibody-Dependent Enhancement (ADE)

  Affiliation: School of Zoology, George S. Wise Faculty of Life Sciences, Tel Aviv University

- Matthias Maier (MS02, Griffin 301, page 17)

  Time: Saturday (11/4) 02:00 pm - 02:30 pm

  Title: Structure-preserving finite-element schemes for the Euler-Poisson equations

  Affiliation: Texas A&M University

- Tal Malinovitch (MS12, Oliver 101, page 48)

  Time: Saturday (11/4) 02:30 pm - 03:00 pm

  Title: Ballistic motion for Schördigner operators in a periodic strip model

  Affiliation: Rice University

- Alexander Mamonov (MS21, Oliver 116, page 74)

  Time: Saturday (11/4) 10:15 am - 10:45 am

  Title: Waveform inversion via reduced order modeling

  Affiliation: University of Houston

- Felice Manganiello (MS22, Griffin 215, page 75)

  Time: Saturday (11/4) 10:15 am - 10:45 am

  Title: Generic Error SDP and Generic Error CVE

  Affiliation: Clemson University

- Austin Marstaller (MS11, Oliver 112, page 47)

  Time: Saturday (11/4) 10:45 am - 11:15 am

  Title: Dynamics and localization in the discrete fractional nonlinear Schrödinger Equation

  Affiliation: Southern Methodist University

- Daniel Massatt (MS04, Griffin 302, page 24)

  Time: Saturday (11/4) 10:15 am - 10:45 am

  Title: Mathematical Models of Topologically Protected Transport in Electrically Gated Twisted Bilayer Graphene

  Affiliation: Louisiana State University

- Tyler Masthay (MS21, Oliver 116, page 74)

  Time: Saturday (11/4) 10:45 am - 11:15 am

  Title: Optimal Transport for Elastic Source Inversion

  Affiliation: University of Texas at Austin

- Mikhail Mazin (MS18, Griffin 202, page 67)

  Time: Saturday (11/4) 01:30 pm - 02:00 pm

  Title: Triangular Partitions

  Affiliation: Kansas State University

- Shane A. McQuarrie (MS33, Griffin 305, page 106)

  Time: Saturday (11/4) 09:45 am - 10:15 am

  Title: Learning Reduced Operators with Gaussian Processes

  Affiliation: Sandia National Laboratories

- Taoufik Meklachi (MS10, Oliver 112, page 41)

  Time: Saturday (11/4) 02:30 pm - 03:00 pm

  Title: Spectral analysis of scattering resonances with application on high-contrast nanospheres

  Affiliation: Penn State

- Giacomo Micheli (MS22, Griffin 215, page 75)

  Time: Saturday (11/4) 09:45 am - 10:15 am

  Title: On a Class of Optimal Locally Recoverable Codes with Availability

  Affiliation: University of South Florida

- Weston Miller (MS18, Griffin 202, page 70)

  Time: Sunday (11/5) 10:15 am - 10:45 am

  Title: Rational Catalan Numbers for Complex Reflection Groups

  Affiliation: University of Texas at Dallas

- Susan E. Minkoff (MS21, Oliver 116, page 74)

  Time: Saturday (11/4) 09:45 am - 10:15 am

  Title: A comparison of extension methods for seismic inversion

  Affiliation: University of Texas at Dallas

- Sambit Mishra (MS02, Griffin 301, page 16)

  Time: Saturday (11/4) 11:15 am - 11:45 am

  Title: Online Bayesian Optimization of Polynomial-Multigrid Cycles for Flux Reconstruction

  Affiliation: Texas A&M University

- Christopher Mitchell (MS23, Oliver 119A, page 80)

  Time: Saturday (11/4) 10:45 am - 11:15 am

  Title: Importance of underlying mechanisms for interpreting relative risk of Clostridioides difficile infection among antibiotic-exposed patients in healthcare facilities

  Affiliation: Tarleton State University

- Kirsten Morris (MS22, Griffin 215, page 76)

  Time: Saturday (11/4) 11:15 am - 11:45 am

  Title: Graphical Characterization of Decoding Failures for Quantum LDPC Codes

  Affiliation: University of Nebraska-Lincoln

- Shari Moskow (MS10, Oliver 112, page 41)

  Time: Saturday (11/4) 01:30 pm - 02:00 pm

  Title: The Lippmann Schwinger Lanczos algorithm for inverse scattering problems

  Affiliation: Drexel University

- Fahad Mostafa (MS32, Griffin 204, page 102)

  Time: Saturday (11/4) 10:15 am - 10:45 am

  Title: Improved Graph Based Statistical Clustering Techniques with Application to Breast Cancer Image Segmentation

  Affiliation: Texas Tech University

- Quiyana M. Murphy (MS19, Oliver 117, page 72)

  Time: Sunday (11/5) 12:30 pm - 01:00 pm

  Title: Understanding Neutrophil Dynamics during Covid-19 Infection

  Affiliation: Virginia Tech Department of Mathematics

- Cyrus Neary (MS33, Griffin 305, page 107)

  Time: Saturday (11/4) 10:45 am - 11:15 am

  Title: Incorporating Physics-Based Knowledge into Neural Differential Equations for the Modeling and Control of Robotic Systems

  Affiliation: The University of Texas at Austin

- Garrett Nelson (MS18, Griffin 202, page 69)

  Time: Saturday (11/4) 04:15 pm - 04:45 pm

  Title: Periodic Points of Parking Functions

  Affiliation: Kansas State University

- Jay Newby (MS31, Oliver 119A, page 101)

  Time: Saturday (11/4) 03:00 pm - 03:30 pm

  Title: Extreme first passage times for populations of identical rare events

  Affiliation: University of Alberta

- Aria Nosratinia (MS22, Griffin 215, page 79)

  Time: Sunday (11/5) 11:30 am - 12:00 pm

  Title: On the Performance Evaluation of Wiretap Codes

  Affiliation: University of Texas at Dallas

- Brighton Nuwagira (MS30, Griffin 144, page 98)

  Time: Friday (11/3) 03:30 pm - 04:00 pm

  Title: Topological Data Analysis in Medical Imaging

  Affiliation: University of Texas at Dallas

- Daniel Onofrei (MS10, Oliver 112, page 42)

  Time: Saturday (11/4) 03:00 pm - 03:30 pm

  Title: On the problem of personalized sound

  Affiliation: University of Houston

- Tamer Oraby (MS24, Oliver 117, page 83)

  Time: Saturday (11/4) 03:00 pm - 03:30 pm

  Title: Vaccination Acceptance of Rational and Boundedly Rational Parents

  Affiliation: The University of Texas Rio Grande Valley

- William Ott (MS31, Oliver 119A, page 100)

  Time: Saturday (11/4) 01:30 pm - 02:00 pm

  Title: Noisy delay denoises biochemical oscillators

  Affiliation: University of Houston

- Yerbol Palzhanov (MS03, Griffin 302, page 20)

  Time: Sunday (11/5) 09:45 am - 10:15 am

  Title: A scalar auxiliary variable unfitted FEM for the surface Cahn-Hilliard equation

  Affiliation: University of Houston

- Narendra Pant (MS34, Oliver 119A, page 109)

  Time: Sunday (11/5) 11:00 am - 11:30 am

  Title: The dynamics of a discrete-time predator-prey model with predator evolution and periodic prey reproduction

  Affiliation: University of Louisiana at Lafayette

- Elzbieta Polak (MS09, Griffin 204, page 40)

  Time: Sunday (11/5) 12:00 pm - 12:30 pm

  Title: Discriminants in Weighted Low-Rank Approximation

  Affiliation: University of Texas at Austin

- Joan Ponce (MS25, Oliver 117, page 86)

  Time: Saturday (11/4) 10:45 am - 11:15 am

  Title: HIV Spread and Treatment Distribution: Two Country Case Studies

  Affiliation: Arizona State University

- Matthew Powell (MS12, Oliver 101, page 48)

  Time: Saturday (11/4) 01:30 pm - 02:00 pm

  Title: Regularity of the Lyapunov exponent for multifrequency quasi-periodic cocycles

  Affiliation: Georgia Institute of Technology

- Charles Puelz (MS28, Oliver 101, page 93)

  Time: Friday (11/3) 03:30 pm - 04:00 pm

  Title: Computer models and image processing to study surgeries for the treatment of single ventricle physiology

  Affiliation: Baylor College of Medicine

- Kunlun Qi (MS08, Griffin 130, page 37)

  Time: Saturday (11/4) 04:15 pm - 04:45 pm

  Title: Stability and convergence analysis of the Fourier-Galerkin spectral method for the Boltzmann equation

  Affiliation: University of Minnesota - Twin Cities

- Yuan Qiu (MS33, Griffin 305, page 106)

  Time: Saturday (11/4) 10:15 am - 10:45 am

  Title: Derivative-informed Deep Operator Network

  Affiliation: Georgia Institute of Technology

- Zhuolin Qu (MS25, Oliver 117, page 85)

  Time: Saturday (11/4) 09:45 am - 10:15 am

  Title: Modeling Immunity to Malaria with an Age-Structured PDE Framework

  Affiliation: University of Texas at San Antonio

- Mohammad Mahabubur Rahman (MS05, Griffin 129, page 29)

  Time: Sunday (11/5) 11:30 am - 12:00 pm

  Title: Global Regularity Issue of the Hall-Magnetohydrodynamics System

  Affiliation: Sam Houston State University

- Saburi Rasheed (MS19, Oliver 117, page 71)

  Time: Sunday (11/5) 12:00 pm - 12:30 pm

  Title: A mathematical model of tuberculosis and diabetes co-infection dynamics with saturated treatment

  Affiliation: University of Louisiana at Lafayette

- Carlos Nicolas Rautenberg (MS03, Griffin 302, page 20)

  Time: Sunday (11/5) 10:15 am - 10:45 am

  Title: Variational Problems in Measure Spaces with Regular Divergences and Mixed Boundary Conditions

  Affiliation: George Mason University

- Vinicio Rios (MS27, Griffin 203, page 90)

  Time: Friday (11/3) 03:00 pm - 03:30 pm

  Title: Approximations of optimal solutions of a Mayer problem for a controlled and time-delayed perturbed sweeping process

  Affiliation: Louisiana State University

- Beatrice Riviere (MS07, Griffin 130, page 32)

  Time: Friday (11/3) 03:00 pm - 03:30 pm

  Title: Mixed Hybrid and Hybridizable Discontinuous Galerkin Method for Flow and Transport

  Affiliation: Rice University

- Beatrice Riviere (MS13, Griffin 144, page 52)

  Time: Saturday (11/4) 01:30 pm - 02:00 pm

  Title: Bound-Preserving Discontinuous Galerkin Solutions for Compressible Two-Phase Flows

  Affiliation: Rice University

- Jonah Robinson (MS06, Griffin 201, page 30)
  Time: Saturday (11/4) 02:30 pm - 03:00 pm
  Title: Invariants of the Dispersion Relation for Discrete Periodic Operators
  Affiliation: Texas A&M
- Benno Rumpf (MS26, Oliver 116, page 88)
  Time: Saturday (11/4) 01:30 pm - 02:00 pm
  Title: Cold discrete breathers
  Affiliation: Southern Methodist University
- Naufil Sakran (MS15, Griffin 305, page 60)
  Time: Saturday (11/4) 03:00 pm - 03:30 pm
  Title: Unipotent Numerical Semigroups
  Affiliation: Tulane University
- Rodrigo San-José (MS22, Griffin 215, page 77)
  Time: Saturday (11/4) 03:00 pm - 03:30 pm
  Title: Subfield subcodes of projective Reed-Solomon codes
  Affiliation: Universidad de Valladolid
- William A. Sands (MS08, Griffin 130, page 35)
  Time: Saturday (11/4) 01:30 pm - 02:00 pm
  Title: An S_N Discretization with Angular Adaptivity for Radiative Transfer Applications
  Affiliation: University of Delaware
- Hal Schenck (MS06, Griffin 201, page 31)
  Time: Saturday (11/4) 04:15 pm - 04:45 pm
  Title: Kuramoto Oscillators: Algebra and Topology
  Affiliation: Auburn University
- Georgy Scholten (MS09, Griffin 204, page 40)
  Time: Sunday (11/5) 12:30 pm - 01:00 pm
  Title: Rational approximations for computing critical points of analytic functions
  Affiliation: Lip6 - LJLL, Sorbonne Université
- Georgy Scholten (MS16, Griffin 203, page 63)
  Time: Saturday (11/4) 01:30 pm - 02:00 pm
  Title: Global Minimization of Analytic Functions over Compact Domains
  Affiliation: Sorbonne Université

- Paul Schwering (MS03, Griffin 302, page 21)

  Time: Sunday (11/5) 12:00 pm - 12:30 pm

  Title: An Eulerian finite element method for tangential Navier-Stokes equations on evolving surfaces

  Affiliation: Institut für Geometrie und Praktische Mathematik, RWTH Aachen University

- Benjamin Seeger (MS26, Oliver 116, page 89)

  Time: Saturday (11/4) 02:00 pm - 02:30 pm

  Title: Weak solutions of nonlinear, nonconservative transport systems

  Affiliation: University of Texas at Austin

- Hewan Shemtaga (MS11, Oliver 112, page 45)

  Time: Friday (11/3) 03:30 pm - 04:00 pm

  Title: A Chemotaxis Model With A Logistic Source On a Compact Graph

  Affiliation: Auburn University

- Madison Sheridan (MS02, Griffin 301, page 17)

  Time: Saturday (11/4) 02:30 pm - 03:00 pm

  Title: Invariant Domain Preserving and Exactly Conservative Approximation of the Lagrangian Hydrodynamics Equations

  Affiliation: Texas A&M University

- Junping Shi (MS23, Oliver 119A, page 79)

  Time: Saturday (11/4) 09:45 am - 10:15 am

  Title: Modelling Phytoplankton-Virus Interactions: Phytoplankton Blooms and Lytic Virus Transmission

  Affiliation: College of William & Mary

- Stephen P. Shipman (MS04, Griffin 302, page 23)

  Time: Friday (11/3) 04:00 pm - 04:30 pm

  Title: Spectrum of the Neumann-Poincaré operator for thin doubly connected domains

  Affiliation: Louisiana State University at Baton Rouge

- Stephen P. Shipman (MS12, Oliver 101, page 50)

  Time: Sunday (11/5) 11:00 am - 11:30 am

  Title: Defect states in the continuum of Bernal stacked graphene

  Affiliation: Louisiana State University at Baton Rouge

- Aleksandra Sobieska (MS15, Griffin 305, page 60)

  Time: Saturday (11/4) 02:00 pm - 02:30 pm

  Title: Minimal Free Resolutions of Numerical Semigroup Algebras Via Apery Specializations

  Affiliation: University of Wisconsin

- Frank Sottile (MS12, Oliver 101, page 49)

  Time: Saturday (11/4) 04:15 pm - 04:45 pm

  Title: Bloch Discriminants

  Affiliation: Texas A&M University

- Frank Sottile (MS14, Griffin 201, page 58)

  Time: Saturday (11/4) 09:45 am - 10:15 am

  Title: Welschinger Signs and the Wronskii map

  Affiliation: Texas A&M University

- Ananth Vedururu Srinivas (MS34, Oliver 119A, page 110)

  Time: Sunday (11/5) 12:00 pm - 12:30 pm

  Title: Synchronization of Clusters of Pulse Coupled Oscillators with Synaptic Delays

  Affiliation: Louisiana State University Health Sciences Center, New Orleans

- Amit N Subrahmanya (MS10, Oliver 112, page 43)

  Time: Sunday (11/5) 09:45 am - 10:15 am

  Title: Randomized Preconditioners for SC-4DVAR

  Affiliation: Virginia Tech

- Alexey Sukhinin (MS11, Oliver 112, page 47)

  Time: Saturday (11/4) 11:15 am - 11:45 am

  Title: New perspective on modeling high power light propagation in nonlinear media

  Affiliation: University of North Carolina at Greensboro

- Jiguang Sun (MS03, Griffin 302, page 19)

  Time: Saturday (11/4) 02:30 pm - 03:00 pm

  Title: Computational Methods for Scattering Resonances

  Affiliation: Michigan Technological University

- Zheng Sun (MS08, Griffin 130, page 37)

  Time: Sunday (11/5) 10:15 am - 10:45 am

  Title: Oscillation-Eliminating Discontinuous Galerkin Methods for Hyperbolic Conservation Laws

  Affiliation: The University of Alabama

- Zheng Sun (MS13, Griffin 144, page 53)

  Time: Saturday (11/4) 03:45 pm - 04:15 pm

  Title: The Runge–Kutta discontinuous Galerkin method with compact stencils for hyperbolic conservation laws

  Affiliation: The University of Alabama

- Justin Swain (MS02, Griffin 301, page 13)

  Time: Friday (11/3) 03:00 pm - 03:30 pm

  Title: Efficient Numerical Schemes for the **Q**-Tensor Model of Nematic Liquid Crystals

  Affiliation: University of North Texas

- Nusrat Tabassum (MS34, Oliver 119A, page 109)

  Time: Sunday (11/5) 10:15 am - 10:45 am

  Title: Temperature-Dependent Competitive Dynamics of Two Invasive Mosquito Species in Larval Stage

  Affiliation: Texas Tech University

- Tingting Tang (MS32, Griffin 204, page 103)

  Time: Saturday (11/4) 11:15 am - 11:45 am

  Title: Identifiability of compartment models for infectious diseases under both perfect and flawed data

  Affiliation: San Diego State University

- Andrei Tarfulea (MS26, Oliver 116, page 89)

  Time: Saturday (11/4) 03:00 pm - 03:30 pm

  Title: Decay Estimates for the non-cutoff Boltzmann equation

  Affiliation: Louisiana State University

- Christina G. Taylor (MS07, Griffin 130, page 33)

  Time: Saturday (11/4) 10:15 am - 10:45 am

  Title: Energy stable state redistribution cut-cell discontinuous Galerkin methods for wave propagation

  Affiliation: Rice University

- Marco Tezzele (MS29, Griffin 129, page 97)

  Time: Saturday (11/4) 03:00 pm - 03:30 pm

  Title: Predictive digital twins for the structural health monitoring of civil structures

  Affiliation: The University of Texas at Austin

- Travis B. Thompson (MS28, Oliver 101, page 92)

  Time: Friday (11/3) 03:00 pm - 03:30 pm

  Title: The role of clearance in neurodegenerative diseases

  Affiliation: Texas Tech University

- Chenyu Tian (MS05, Griffin 129, page 28)

  Time: Sunday (11/5) 09:45 am - 10:15 am

  Title: Numerical methods for equations governing partial melting materials

  Affiliation: University of Texas at Austin

- Astrit Tola (MS30, Griffin 144, page 98)

  Time: Friday (11/3) 03:00 pm - 03:30 pm

  Title: Relative Growth as a Topological Graph Invariant

  Affiliation: University of Texas at Dallas

- Eduardo Servin Torres (MS05, Griffin 129, page 26)

  Time: Friday (11/3) 03:30 pm - 04:00 pm

  Title: A study of a time-space nonuniform finite difference approximation of the Kawarada equation solutions

  Affiliation: Baylor University

- Minh Binh Tran (MS26, Oliver 116, page 89)

  Time: Saturday (11/4) 02:30 pm - 03:00 pm

  Title: Some Recent Results On Wave Turbulence Theory

  Affiliation: Texas A&M University

- John Treuer (MS17, Griffin 304, page 65)

  Time: Saturday (11/4) 11:15 am - 11:45 am

  Title: The Levi Core

  Affiliation: University of California San Diego

- Bilyana Tzolova (MS28, Oliver 101, page 94)

  Time: Saturday (11/4) 10:45 am - 11:15 am

  Title: Flow and Transport in the Liver Organ

  Affiliation: Rice University

- Nate Vaduthala (MS16, Griffin 203, page 64)

  Time: Saturday (11/4) 02:30 pm - 03:00 pm

  Title: Flag Matroids as Greedoids

  Affiliation: Tulane University

- Bradley Vigil (MS28, Oliver 101, page 93)

  Time: Friday (11/3) 04:00 pm - 04:30 pm

  Title: Networks, Topology, Data and Pathology

  Affiliation: Texas Tech University

- An Vu (MS02, Griffin 301, page 14)

  Time: Friday (11/3) 04:30 pm - 05:00 pm

  Title: Semi-implicit projection methods for incompressible flows with variable density coupled with the temperature equation

  Affiliation: University of Houston

- Bart van Bloemen Waanders (MS10, Oliver 112, page 42)

  Time: Saturday (11/4) 03:45 pm - 04:15 pm

  Title: Hyper-Differential Sensitivity Analysis with respect to Model Discrepancy: Optimal Experimental Design

  Affiliation: Sandia National Laboratories

- Shawn W. Walker (MS03, Griffin 302, page 21)

  Time: Sunday (11/5) 11:00 am - 11:30 am

  Title: Computing the Shape Operator with the HHJ Method

  Affiliation: Louisiana State University

- Chunmei Wang (MS13, Griffin 144, page 53)

  Time: Saturday (11/4) 03:00 pm - 03:30 pm

  Title: Friedrichs Learning for PDEs

  Affiliation: University of Florida

- Jidong Wang (MS16, Griffin 203, page 62)

  Time: Saturday (11/4) 10:15 am - 10:45 am

  Title: Statistics via tropical geometry

  Affiliation: UT Austin

- Lihan Wang (MS05, Griffin 129, page 27)

  Time: Saturday (11/4) 04:15 pm - 04:45 pm

  Title: Accelerate Sampling Using Birth-Death Dynamics

  Affiliation: Carnegie Mellon University

- Zuodong Wang (MS02, Griffin 301, page 17)

  Time: Saturday (11/4) 03:00 pm - 03:30 pm

  Title: Asymptotic-preserving and invariant-preserving schemes for hyperbolic conservation laws with stiff reaction source term

  Affiliation: Ecole des Ponts ParisTech, France

- Aaron Welters (MS04, Griffin 302, page 22)

  Time: Friday (11/3) 03:00 pm - 03:30 pm

  Title: Spectral theory for linear periodic DAEs arising in the electrodynamics of 1D photonic crystals

  Affiliation: Florida Institute of Technology

- Zheyu Wen (MS10, Oliver 112, page 43)

  Time: Sunday (11/5) 10:15 am - 10:45 am

  Title: Uncertainty Quantification in the Inverse Problem of Temporal Dynamic Systems for Medical Imaging: An Application to Alzheimer's Disease

  Affiliation: The University of Texas at Austin

- Kyle Williams (MS30, Griffin 144, page 99)

  Time: Saturday (11/4) 10:15 am - 10:45 am

  Title: Evader Detection In 3-Dimensional Mobile Sensor Networks

  Affiliation: University of Houston

- Nathan Williams (MS18, Griffin 202, page 69)

  Time: Sunday (11/5) 09:45 am - 10:15 am

  Title: Trees from Affine Braid Varieties

  Affiliation: University of Texas at Dallas

- Corey Wolfe (MS15, Griffin 305, page 62)

  Time: Sunday (11/5) 10:15 am - 10:45 am

  Title: On the Nilpotent Subsemigroups of M_n and MSp_n

  Affiliation: Tulane University

- Derek Wu (MS14, Griffin 201, page 58)

  Time: Saturday (11/4) 10:15 am - 10:45 am

  Title: Border rank bounds for $GL(V)$-invariant tensors arising from matrices of constant rank

  Affiliation: Texas A&M University

- Bryant Wyatt (MS05, Griffin 129, page 28)

  Time: Sunday (11/5) 11:00 am - 11:30 am

  Title: Modeling Supraventricular Tachycardia Using Dynamic Computer-Generated Left Atrium

  Affiliation: Tarleton State University

- Catherine H. Yan (MS18, Griffin 202, page 69)

  Time: Saturday (11/4) 03:45 pm - 04:15 pm

  Title: 2-Dimensional Vector Parking Functions

  Affiliation: Texas A&M University

- Yonghua Yan (MS01, Griffin 129, page 11)

  Time: Saturday (11/4) 10:15 am - 10:45 am

  Title: Investigating Vortex Interactions in Tandem Micro Vortex Generator Arrangements for Supersonic Flow Control

  Affiliation: Jackson State University, Jackson, Mississippi, USA

- Haizhao Yang (MS13, Griffin 144, page 52)

  Time: Saturday (11/4) 02:00 pm - 02:30 pm

  Title: A Symbolic Approach for Scientific Machine Learning

  Affiliation: University of Maryland College Park

- Yang Yang (MS03, Griffin 302, page 19)

  Time: Saturday (11/4) 03:45 pm - 04:15 pm

  Title: Sign-preserving second-order IMPEC time discretization

  Affiliation: Michigan Technological University

- Yang Yang (MS13, Griffin 144, page 53)

  Time: Saturday (11/4) 02:30 pm - 03:00 pm

  Title: The reinterpreted discrete fracture model

  Affiliation: Michigan Technological University

- Yong Yang (MS01, Griffin 129, page 12)

  Time: Saturday (11/4) 10:45 am - 11:15 am

  Title: Advancements in 3D High-Density Ratio Two-Phase Lattice Boltzmann Method for Capturing Complex Fluid Dynamics

  Affiliation: West Texas A&M University, Canyon, Texas, USA

- Yuliia Yershova (MS12, Oliver 101, page 51)

  Time: Sunday (11/5) 12:30 pm - 01:00 pm

  Title: Norm-resolvent convergence for Neumann Laplacians on manifolds thinning to graphs

  Affiliation: Texas A&M University

- Peimeng Yin (MS13, Griffin 144, page 56)

  Time: Sunday (11/5) 12:00 pm - 12:30 pm

  Title: A semi-implicit dynamical low-rank discontinuous Galerkin method for space homogeneous kinetic equations

  Affiliation: University of Texas at El Paso

- Shiming Yuan (MS01, Griffin 129, page 11)

  Time: Saturday (11/4) 09:45 am - 10:15 am

  Title: Evaluating Modern High-Resolution WENO Schemes for Supersonic Flow Simulations

  Affiliation: Jackson State University, Jackson, Mississippi, USA

- Yukun Yue (MS03, Griffin 302, page 18)

  Time: Saturday (11/4) 01:30 pm - 02:00 pm

  Title: On convergence analysis of an IEQ-based numerical scheme for hydrodynamical Q-tensor model

  Affiliation: University of Wisconsin-Madison

- Mikhail Zaslavsky (MS10, Oliver 112, page 44)

  Time: Sunday (11/5) 11:30 am - 12:00 pm

  Title: Completed-data-driven ROMs for SAR imaging

  Affiliation: Southern Methodist University

- Jonathan Zhang (MS07, Griffin 130, page 34)

  Time: Saturday (11/4) 10:45 am - 11:15 am

  Title: A study of linear elasticity with DPG, and the nonlinear Cook's Membrane problem

  Affiliation: University of Texas at Austin

- Rui Zhang (MS05, Griffin 129, page 29)

  Time: Sunday (11/5) 12:00 pm - 12:30 pm

  Title: Seismic sparse-layer reflectivity inversion using basis pursuit decomposition

  Affiliation: University of Louisiana at Lafayette

- Shuang Zhang (MS29, Griffin 129, page 95)

  Time: Saturday (11/4) 01:30 pm - 02:00 pm

  Title: Tracking multi-scale river responses to enhanced rock weathering

  Affiliation: Texas A&M University

- Yifan Zhang (MS09, Griffin 204, page 40)

  Time: Sunday (11/5) 11:30 am - 12:00 pm

  Title: Applications of Real Algebraic Geometry to Neural Networks and Optimization

  Affiliation: University of Texas at Austin

- Nanyi Zheng (MS13, Griffin 144, page 56)

  Time: Sunday (11/5) 12:30 pm - 01:00 pm

  Title: A fourth-order conservative semi-Lagrangian finite volume WENO scheme without operator splitting for kinetic and fluid simulations

  Affiliation: University of Delaware

- Zequn Zheng (MS27, Griffin 203, page 92)

  Time: Friday (11/3) 04:30 pm - 05:00 pm

  Title: Generating Polynomial Method for Non-symmetric Tensor Decomposition

  Affiliation: Louisiana State University

- Yimin Zhong (MS08, Griffin 130, page 35)

  Time: Saturday (11/4) 02:30 pm - 03:00 pm

  Title: Fast solver for radiative transfer based on integral formulation

  Affiliation: Auburn University

- Jinpu Zhou (MS10, Oliver 112, page 44)

  Time: Sunday (11/5) 12:30 pm - 01:00 pm

  Title: Bayesian nonparametric learning of stochastic differential equations

  Affiliation: Department of Mathematics, Louisiana State University

- Xiaowen Zhu (MS12, Oliver 101, page 50)

  Time: Sunday (11/5) 09:45 am - 10:15 am

  Title: Closure of bulk spectral gaps for topological insulator with general edges

  Affiliation: University of Washington

- John Zweck (MS11, Oliver 112, page 46)

  Time: Friday (11/3) 04:00 pm - 04:30 pm

  Title: A split-step method for a nonlinear nonlocal wave equation with applications to laser stability

  Affiliation: University of Texas at Dallas

Abstracts of Poster Presentations

Time: Saturday (11/4) 05:55 pm-06:25 pm
Venue: Griffin 1st and 2nd floors

Adedolapo Akinde

Title: Multi-Integer Linear Programming (MILP) in Single Site Decision Making for Biomass Energy Facility
Affiliation: University of North Carolina at Charlotte, NC
Abstract: This research applies Decision Science mathematical modeling for solving an optimization (cost minimization) problem in siting of a single biomass power generation facility. Optimization of an accessibility measure to power generation is the aim of this research. The p-median problem is employed here to site a biomass power plant by recognizing the best facility location and allocation. The decision is whether a potential biomass power plant site j is selected, Yj, and to determine which power plant site serves a state i, Xij, in the country. It is assumed that the relative cost of construction and operation of a biomass power plant is the same across demand areas. One constraint is that each demand area is allocated to a power plant, that is, each demand area must be served. The minimization objective and constraints ensures that allocation of each demand is to the closest biomass power facility. Thus, the location-allocation model solves a p-median problem, which is an integer-linear programming problem. This model has seven siting decision variables and 42 allocation decision variables. The model also has six allocation constraints, 42 constraints limiting assignment to open a single facility and one constraint that specifies the number of facilities to be sited (p = 1). Model structure depicts a mixed integer linear programming problem (MILP) as all expressions are linear, and a subset of the variables is restricted to integer values. The commercial software package, LINGO, is employed in this study. LINGO runs on Python programming language. Model structure follows the structure of an algebraic statement. Data specification for the model is at the bottom of the LINGO file. From the output, there is a global optimal solution. Table of result findings presents a summary of the optimal location and the minimization objective value. Keywords: optimization, location-allocation, multi-integer linear programming (MILP)
Authors: Adedolapo Akinde (University of North Carolina at Charlotte, NC) and Osawe Wellington (University College Dublin)

Kalana Kushan Munasinghe Arachchige

Title: Identification of factors and classifying the accident severity in Colombo - Katunayake expressway, Sri Lanka
Affiliation: Texas Tech University
Abstract: Since its inception in 2011, Sri Lanka's expressway system, comprising three major expressways, has seen a growing preference among users due to its efficiency, reduced traffic, and ease of driving. Alarmingly, recent police reports highlight an increasing trend in accident occurrences, with the Colombo-Katunayake Expressway registering the highest frequency, an area yet to be studied in depth. This research aims to elucidate factors contributing to these accidents on the Colombo-Katunayake Expressway and to craft machine learning models to categorize the severity of the mishaps. Data from 704 accidents between 2013-2019 were analyzed. Utilizing the Chi-square test, logistic regression, and Kruskal-Wallis tests, we discerned an association between accident severity and seven influential variables derived from

literature review. These variables include time category, driver's age category, vehicle type, reason for accident, number of vehicles involved, cause for accident and rainfall conditions, each significant at a 5% level. Addressing the dataset's class imbalance, a random under-sampling technique was employed. Subsequently, we applied the Naïve Bayes classification algorithm and the Probabilistic Neural Network (PNN) for severity prediction, achieving an overall classification accuracy of 72.14% and 74.29% respectively. While both models are adept at predicting severity on the Colombo-Katunayake expressway, the PNN demonstrated marginally superior accuracy. Our findings and models stand to inform and drive safety enhancements on Sri Lanka's expressways, potentially reducing accident rates.
Authors: Kalana Kushan Munasinghe Arachchige (Texas Tech University, USA) and Nishani Vasana Chandrasekara (University of Kelaniya, Sri Lanka)

Boluwatife Awoyemi

Title: Fitting a Compartmental Model of Competing Mosquito Species to Abundance Data
Affiliation: Texas Tech University
Abstract: The Aedes Aegypti mosquito (Yellow fever mosquito) and the Aedes Albopictus mosquito (Tiger mosquito) are known to share some characteristics including spreading similar viruses, but the coexistence of the two mosquito species in the same area can lead to the deterioration or obliteration of one of the species through interspecific competition with temperature dependence. Our model is a 4-compartment ordinary differential equation model that accounts for both mosquito larva species with their competition parameters and their pupation. We designed an experiment using different ratios of the larvae of both mosquito species, with limited food quantities administered to amplify competition. The experimental design was implemented at four different temperatures. The number of larvae in each container was counted every other day as the larvae transitioned to pupae, adult mosquitoes emerged from pupae, and the adult mosquitoes' species were identified. We fit the data to our model, and we analyzed the data collected using the programming language R. We observed the trends in larva termination for each temperature, compared the prediction of the fitted results for the number of each mosquito species that could have possibly emerged to the actual number of adult mosquitoes recorded in the data. We ascertained the dominant mosquito species that has a higher chance of annihilating its competition when found in the same location, as a function of/ dependent on temperature.
Authors: Boluwatife Awoyemi (Texas Tech University), Nusrat Tabassum (Texas Tech University), A-manda Laubmeier(Texas Tech University), Joseph McMillan(Texas Tech University)

Kenneth Beard

Title: Matrix monotonicity and concavity of the principal pivot transform
Affiliation: University of Louisiana
Abstract: In this poster, we present our recent result on the matrix monotonicity of the principal pivot transform (PPT) in the Löewner ordering on Hermitian matrices. This is followed by a minimization principle for the PPT, which is then used to establish matrix concavity of the PPT for kernel equivalent positive semi-definite matrices. These results utilize the fundamental properties of Schur complements and the Moore-Penrose pseudoinverse under the Löewner ordering.
Authors: Kenneth Beard (University of Louisiana) and Aaron Welters (Florida Institute of Technology)

Difeng Cai

Title: Efficient Data-driven Hierarchical Matrix Computation for General Kernels
Affiliation: Southern Methodist University
Abstract: Hierarchical matrix representation is a powerful data-sparse format for accelerating dense kernel matrix computations in N-body simulations, integral equations, statistical inference, etc. Though the representation enables fast matrix operations (in optimal or nearly optimal complexity), many algorithms to construct such a hierarchical representation often requires high computational costs and special properties of the kernel function. Moreover, the performance may deteriorate for high dimensional data and complex geometries. To resolve these challenges, we propose a data-driven approach to construct the hierarchical matrix that is memory-efficient, applicable to general kernel functions and data sets in over three dimensions. Numerical experiments show the advantage of the data-driven approach for high dimensional data and benchmark tests demonstrate that the new approach can achieve better performance than the state-of-the-art packages, especially for data from complex manifolds.
Authors: Difeng Cai (Southern Methodist University), Edmond Chow (Georgia Institute of Technology), Lucas Erlandson (Lawrence Livermore National Lab), Hua Huang (Georgia Institute of Technology), Yuanzhe Xi (Emory University)

Kody Chabaud

Title: Elliptic Curve Cryptography and Serpent to Send Secure Messages Across a Public Chain
Affiliation: Southeastern Louisiana University
Abstract: Serpent is a symmetric encryption algorithm used to encrypt and decrypt strings. Though a fast algorithm, it is not considered necessarily secure. Combining this symmetric algorithm with an asymmetric one, such as elliptic curve cryptography, yields an extremely secure and efficient algorithm. Doing so can prove useful for a number of implications, such as transactions, data security, and message sharing. For our specific usage case, we are pairing the two together to create a secure messaging app where individual or group messages can be sent without worry of information leaks. Also to be shown: C script developed to generate elements in a cyclic group to be used in elliptic curve cryptography, given the equation and starting point.
Authors: Kody Chabaud (Southeastern Louisiana University

Sajal Chakroborty

Title: On the use of the M-quantiles for outlier detection in multivariate data
Affiliation: Department of Mathematics and Statistics, Texas Tech University, USA
Abstract: Outliers are data points that lie in the low-density region of the underlying probability distribution in the sample space. The two most commonly used methods that try to estimate low-density regions to detect outliers in data are distance-based methods and statistical methods. The distance-based methods compute an anomaly score for each data point by either counting the number of nearest neighbors in a hypersphere centered at the data point or the distance between the data point and the k-th nearest neighbor. The statistical methods use a depth function as a generalization of the quantile function in one dimension. Starting in the 1990s, an elegant theory of depth called M-quantiles that combined convex analysis and probability theory appeared in the literature. Applications to biomedicine and extensions to infinite-dimensional data were proposed. In this project, we study the theoretical properties

of M-quantiles to investigate their utility for outlier detection in multivariate data. We show that the M-quantiles are neither a depth function nor useful to estimate low-density regions when the sample space has a dimension greater than 1.
Authors: Sajal Chakroborty, Ram Iyer, Alex Trindade (Texas Tech University, USA)

Indika Gihan Gunawardana Ilandari Dewage

Title: Predicting CO and NO_x Emissions from Gas Turbine
Affiliation: Texas Tech University
Abstract: In this study, data gathered in Turkey between 2011 and 2015 were used to examine CO and NO_x emissions using the Predictive Emission Monitoring System (PEMS). PEMS examines a number of variables, such as the surrounding temperature, to determine hourly gas emissions. The turbine inlet temperature (TIT), which has a considerable impact on CO production, and other turbine characteristics were shown to be significantly correlated with CO, according to a thorough correlation analysis. In contrast, NO_x showed a strong association with the surrounding temperature, indicating the need for operational changes to lower emissions. The study utilized machine learning strategies when it became clear that there were no linear trends. The initial strategy used linear regression, then bagged regression trees were implemented, which improved prediction accuracy by combining the efforts of weak learners. Additionally, an Artificial Neuron Network was created using training, testing, and validation sets of data. The study came to the conclusion that factors like TIT are crucial for predicting emissions. Notably, the Bagged regression trees method produced encouraging outcomes, particularly in predicting CO levels, and provided insightful information for optimizing gas turbine operations to reduce environmental effects.
Authors: Indika Gihan Gunawardana Ilandari Dewage (Texas Tech University)

Jaryd Domine

Title: Waves in black hole geometries: An energy-based discontinuous Galerkin method
Affiliation: Southern Methodist University
Abstract: The geometry of spacetime in the vicinity of a black hole directs not only the movement of particles, but the propagation of waves. The authors present an energy-based discontinuous Galerkin method (EDG-GR) for the simulation of waves in black hole geometries, distinguished in that (1) it is localized, making it efficient and parallelizable; (2) accurate radiation conditions allow simulation over a smaller region while preserving accuracy, and (3) the choice of a first-order time, second-order space (FOTSOS) form greatly reduces the number of fields to be evolved. The presentation highlights the special case of a scalar wave equation in the vicinity of a rotating, uncharged (Kerr) black hole.
Authors: Jaryd Domine (Southern Methodist University), Thomas Hagstrom (Southern Methodist University), and Stephen R. Lau (University of New Mexico)

Kyle Earp

Title: Bayesian Methods to Infer Parameters for ODE Models of Disease Spread
Affiliation: Tarleton State University
Abstract: Classical models of disease outbreaks rely on systems of nonlinear ordinary differential equations. ODE models have been widely successful and are credited with saving millions of lives worldwide.

However, ODE models involve parameters that are often poorly understood and difficult to infer from limited and noisy data. This is especially problematic for rare, novel, or neglected diseases with unreliable reporting mechanisms. While some parameters can be deduced from biological or social facts, many must be inferred from data. Traditional least-squares point-estimates are fragile when applied to noisy data common in disease modeling. Bayesian inference replaces fragile point-estimates with posterior distributions that are more robust against data quality issues. Whereas point-estimate models produce a single outbreak forecast, Bayesian models generate an ensemble of forecasts through repeatedly sampling model parameters from their posterior distributions and numerically solving the resulting ODE. These multiple forecasts can be pooled and statistically analyzed at each time step (min, max, mean, etc) to give insight into potential outbreak scenarios (best-case, worst-case, most likely, resp). This project aims to create well-functioning ODE models using a new mathematical idea called amortized Bayesian inference implemented in the BayesFlow Python library. This exciting new tool was created in 2020 to help fight Covid-19 and other common diseases. This project will enhance the BayesFlow library to compensate for data quality issues and provide the improved models epidemiologists need to effectively fight NTDs.
Authors: Kyle Earp, Derek Hopkins, Amanda Kodua, Tristen Troublefield

Jannatul Ferdous Ema

Title: A Local Macroscopic Conservative (LoMaC) low rank tensor method with the discontinuous Galerkin method for the Vlasov dynamics
Affiliation: Texas Tech University
Abstract: We present a novel Local Macroscopic Conservative (LoMaC) low rank tensor method with discontinuous Galerkin (DG) discretization for the physical and phase spaces for simulating the Vlasov-Poisson (VP) system. The LoMaC property refers to the exact local conservation of macroscopic mass, momentum and energy at the discrete level. The LoMaC low rank tensor algorithm (recently developed in arXiv:2207.00518) simultaneously evolves the macroscopic conservation laws of mass, momentum and energy using the kinetic flux vector splitting; then the LoMaC property is realized by projecting the low rank kinetic solution onto a subspace that shares the same macroscopic observables. This work is a generalization of our previous development, but with DG discretization to take advantage of its compactness and flexibility in handling boundary conditions and its superior accuracy in the long term. The algorithm is developed in a similar fashion as that for a finite difference scheme, by observing that the DG method can be viewed equivalently in a nodal fashion. With the nodal DG method, assuming a tensorized computational grid, one will be able to (1) derive differentiation matrices for different nodal points based on a DG upwind discretization of transport terms, and (2) define a weighted inner product space based on the nodal DG grid points. The algorithm can be extended to the high dimensional problems by hierarchical Tucker decomposition of solution tensors and a corresponding conservative projection algorithm. In a similar spirit, the algorithm can be extended to DG methods on nodal points of an unstructured mesh, or to other types of discretization, e.g. the spectral method in velocity direction. Extensive numerical results are performed to showcase the efficacy of the method.
Authors: Wei Guo (Texas Tech University), Jannatul Ferdous Ema (Texas Tech University) and Jing-Mei Qiu (University of Delaware, Newark)

Julio Cesar Enciso-Alva

Title: New Methods in EEG Source Localization based on EEG and Post-Mortem Pathology Data
Affiliation: University of Texas at Arlington

Abstract: A central task for neuroscience is to determine the location of electrical activity inside the brain. Such electrical signals can be recorded at a high resolution in time (sub-millisecond) but low resolution in space, thus making it difficult to locate its source unambiguously. Further assumptions must be incorporated into the electrical source models to reliably locate this electrical activity inside the brain. One such assumption is to consider the current density distribution and assume that, among all possible configurations, the ones with minimal energy are more likely to be correct. The specifics of implementing this assumption have led to a multitude of methods. However, these minimal-norm methods are limited to the quality of electrical recordings and their low resolution in space. On the paradigm of multi-modal data fusion, the electrical source localization methods are enhanced by considering data from additional imaging modalities. In this work, we propose a simple model using binarized pathology data to enhance electrical source imaging from electroencephalography (EEG) recordings. This study is motivated by post-mortem data on hypoxia due to ischemic stroke, but it may use data derived from fMRI, NIRS, and CT, among others.
Authors: Julio Cesar Enciso-Alva (University of Texas at Arlington) and Jianzhong Su (University of Texas at Arlington)

Irene Erazo

Title: Rigid microspheres in a Stokes fluid: motion due to white noise
Affiliation: Tulane University
Abstract: This study investigates the dynamic behavior of a small spherical particles subjected to externally applied random forces while immersed in a viscous fluid. Our computational approach uses a regularized Stokeslet formulation. In contrast to the stochastic immersed boundary method, which averages fluctuating random forces within the particle location, here, these forces are in the surrounding fluid, external to the particle surfaces. We assume the particles are spheres with rigid rotations and translations due to the applied transient forces. Moreover, the spheres interact through the fluid, and their trajectories and relative motion are investigated.
Authors: Irene Erazo (Tulane University), Scott Mckinley (Tulane University) and Lisa Fauci (Tulane University)

Himali Gammanpila

Title: Stability and Error analysis for Nitche-Type CIP/GP CutFEM Oseen two phase flow
Affiliation: Texas Tech University
Abstract: Two-phase flows are encountered in various industrial applications and natural phenomena. Since the interface is significantly thin in two-phase flow, it can be treated as a discontinuity in the flow field where localized surface tension forces act. Defining the interface implicitly means that elements may be intersected by the interface, and the aforementioned discontinuities may occur inside them. When using the finite element method (FEM) with polynomial shape functions, these discontinuities cannot be explicitly represented. Therefore, many PDE solvers employ a discontinuous function, especially in the context of fluid dynamics problems. These methods utilize discontinuous functions to distinguish different domains and ensure no extrinsic contributions are incurred when utilizing an arbitrary discontinuity. An extension of FEM utilizing discontinuous functions is CutFEM or Extended FEM (XFEM), which allows for reproducing arbitrary discontinuities inside elements by providing an enhanced shape function basis. In this study, a Nitsche-type extended variational multiscale method for two-phase flow is suggested,

specifically for discontinuous pressure. To ensure a stable formulation across the entire domain, Continuous Interior Penalty (CIP) based variational multiscale terms are supported by appropriate face-oriented ghost-penalty terms. These terms are introduced to sufficiently control the enrichment value of the solution fields, thereby ensuring the stability of the formulation. The numerical analysis of the proposed CutFEM starts by providing the bilinear form that satisfies an inf-sup condition with respect to a suitable norm. The inf-sup constant is independent of how the boundary cuts the underlying mesh. Furthermore, energy-type a priori estimates are proved to be independent of the local Reynolds number.
Authors: Himali Gammanpila, Dr. Eugenio Aulisa (Texas Tech University)

Ziad Ghanem

Title: Conjecture on a Generating Set for the Unit Group of the Burnside Ring
Affiliation: University of Texas at Dallas
Abstract: The structure of the unit group of the Burnside Ring $A(G)$ associated with a finite group G is a long-standing open question. We propose that, with knowledge of the irreducible representations of G, the generators of the unit group can be identified with the so-called Basic Degrees from the Brouwer Equivariant Degree.
Authors: Ziad Ghanem (University of Texas at Dallas), Wieslaw Krawcewicz (University of Texas at Dallas)

Kendall Gibson

Title: Modeling the Elastohydrodynamics of Swimming Choanoflagellates
Affiliation: Tulane University
Abstract: A unicellular choanoflagellate has an ovoid cell body and a single flagellum surrounded by a collar of microvilli. By waving its flagellum, it swims and creates a water current that brings bacteria to its collar of microvilli. Alternatively, a thecate cell is not free swimming, but attaches itself to a substrate by a stalk that can deform with flow. Some choanoflagellates, like C. flexa, form colonies that are able to rapidly change their shape due to contraction of the microvilli apparatus. Detailed computational models of choanoflagellate hydrodynamics that capture body morphology typically assume rigid microvilli, rigid stalks, and prescribe the kinematics of the flagellum. However, the flagellum, microvilli, and stalks are not rigid structures, but flexible filaments whose evolving shapes are coupled to their fluid environment. We present a model that treats the flagellum and the microvilli as elastic Kirchhoff rods whose shapes are not pre-set but emerge from the coupled system. In addition to understanding the effect of compliance of these structures on the swimming of a single organism, we will study the hydrodynamic interaction of two choanoflagellates and how the collars might affect this interaction.
Authors: Kendall Gibson, Lisa Fauci, and Ricardo Cortez

Dane Grundvig

Title: Line Search Based Optimization Using Functions with Tunable Accuracy
Affiliation: Rice University
Abstract: We develop a line-search algorithm that uses objective function models with tunable accuracy to solve smooth unconstrained optimization problems. Given a current iterate, traditional line-search

methods use a Taylor expansion to build a quadratic model, and construct a new iterate from an approximate minimizer of this quadratic model. However, in many applications, other effective models of the objective can be constructed for which approximate minimizers can be efficiently computed. We specify how objective function models can be used to generate new iterates in the context of line-search methods, and we specify approximation properties these models have to satisfy. At each iteration, the model has to satisfy function error and relative gradient error tolerances that are determined by the algorithm based on its progress. Moreover, the algorithm assumes that a bound for the model error is available and uses this bound to explore regions where the model is sufficiently accurate. Our algorithm has the same first-order global convergence properties as standard line-search methods. However, our algorithm uses only the models and the model error bounds, but never directly accesses the original objective function. As an example, the algorithm is applied to problems where the evaluation of the objective requires the solution of a large-scale system of nonlinear equations. The models are constructed from reduced order models of this system. Numerical results for partial differential equation constrained optimization problems show the benefits of the proposed algorithm.
Authors: Dane Grundvig (Rice University) and Matthias Heinkenschloss (Rice University)

Rohin Harikumar

Title: A low-rank tensor reconstruction and denoising method for enhancing CNN performance
Affiliation: The University of Texas at Dallas
Abstract: Neural network training data is often corrupted by noise or equipment malfunction leading to incomplete data. We propose a combination of a reconstruction technique and a neural network to deal with data corruption in a machine vision task. Specifically, we consider minimizing the tensor nuclear norm for low-rank data completion and demonstrate its effectiveness using a convolutional neural network (CNN) for image classification. We conduct classification experiments using 3 datasets, showing consistently that CNNs trained on reconstructed images exhibit superior accuracy compared to CNNs trained on corrupted images. Three datasets are examined and in all 3 cases the reconstructed images allow classification of the original ground truth image with improved accuracy ranging from 7-25% over classification from the corrupted data.
Authors: Rohin Harikumar (The University of Texas at Dallas), Susan Minkoff (The University of Texas at Dallas) and Yifei Lou(University of North Carolina at Chapel Hill)

Thilini Karunasena

Title: Decoding Homicide Trends in the USA (1990-2020): A Multi-Dimensional Analysis of Time, Territory, and Socio-Economic Determinants
Affiliation: Texas Tech University
Abstract: This study, covering three decades of homicide rates in the USA from 1990 to 2020, focuses on special state level variations since 2014 and 2021, with a view to providing a complete look at homicide rates across various dimensions. The analysis begins by explaining the importance of understanding homicide trends in the United States, which has been regarded as a fundamental indicator of society's stability and security. In terms of time, the national trend between 1990 and 2020 showed three distinct phases: an initial decline in the 1990s, a period of stabilisation in the 2000s, and a marked recovery in the latter half of 2010s, culminating in a sharp rise in 2020. A state-wise analysis between 2014 and 2021 demonstrated geographical variances, with the states of Louisiana leading in homicide rates between 2014 and 2017, subsequently being overtaken by Mississippi from 2018 to 2021. The need for the understanding

of specific factors and challenges is underlined by these regional differences. Moreover, several factors related to homicide rates over the period 1990 to 2020 were identified in a regression analysis. Factors such as GDP per capita, population density, and unemployment rates were found to significantly influence homicide rates. The reduction in the rate of murder was largely attributable to an increase in GDP per capita and reduced population density. The study's multidimensional approach highlights the multifaceted nature of homicides in the U.S., and it requires comprehensive strategies for taking into account domestic trends, state-specific contexts, and a wide range of socioeconomic determinants.
Authors: Thilini Karunasena (Texas Tech University) and Charu Rajapaksha(Texas Tech University)

Joel Keller

Title: GUI for Harmonic Electromagnetic Waves in Layered Media
Affiliation: LSU
Abstract: The goal of this project is to create a dynamic online application that simulates harmonic electromagnetic (EM) fields in layered media with arbitrary electric and magnetic tensors. This application allows scientists to explore phenomena of scattering, guided modes and resonance in EM layered media and serves as a pedagogical tool for students and professionals. This poster serves as an introduction to the application: an outline of the mathematical theory, an explanation of how to use the application, and a sample of simulations illustrating interesting EM phenomena.
Authors: Stephen Shipman (LSU) Joel Keller (LSU) Anthony Stefan (FIT) and Emma Sandidge (FIT)

Anwar Khaddaj

Title: An All-At-Once Approach to Parameter Estimation in Neuron Models
Affiliation: Department of Computational Applied Mathematics and Operations Research, Rice University
Abstract: Parameter estimation in large-scale compartmental neuron models is an important tool to help advance the understanding of how neurons compute and process sensory information. Traditionally, the majority of computational approaches used in the neuroscience community have formulated these parameter estimation problems as nonlinear least squares problems in the parameters only. In this formulation, each evaluation of the objective function requires the solution of a nonlinear ordinary differential equation (ODE). This leads to highly nonlinear optimization problems that have many local minima and are thus difficult to solve. Instead, the formulation in this poster uses an all-at-once approach which includes the ODE as an explicit constraint and views the parameters and the ODE solution as optimization variables. This decoupling makes the problem less nonlinear and provides opportunities to initialize some optimization variables from measurements. This poster explores initialization strategies and their impact on the solution of the constrained optimization problem using parameter estimation in the Pinsky-Rinzel neuron model.
Authors: Anwar Khaddaj (Rice University), John Steinman (Rice University) and Matthias Heinkenschloss (Rice University)

Samuel Kwan

Title: Markov Chain Modeling of Inelastic Impacts in Energy Harvesters
Affiliation: Rice University

Abstract: We study a vibro-impact energy harvester modeled by a ball in a capsule undergoing harmonic oscillation where energy is harvested through impacts on either end. Previous research assumes that the ball bounces with a constant restitution coefficient **r**, resulting in periodic motion. In practice, **r** tends to vary according to some probability distribution. We consider such a model and show that the relative velocity between the ball and the tube tends towards a limiting probability distribution under certain conditions. We analyze the system as a Markov chain by discretizing velocity and phase (phase is the relative time in which collision happens) and construct probability transition matrices which accurately predict the limiting distribution. We make various approximations to simplify complex behaviors into an alternating impact motion such as using a mathematical "slingshot" to model multiple bouncing on the same side. Under realistic parameters, our model's prediction for long-run behavior matches numerical simulations. We further prove, using Tarjan's algorithm, that there exists a steady state distribution under our model as long as certain conditions for **r** are met. The most important condition being that **r** has a sufficient range. Our results allow us to confidently infer the existence of a limiting distribution in reality and accurately predict what the distribution is. Future work may find good approximations for the average energy harvesting capabilities of this model.
Authors: Samuel Kwan (Rice University), Aaron Lee (University of California, Davis), Rachel Kuske (Georgia Institute of Technology)

Sang-Eun Lee

Title: Collective Dynamics of Self-avoidant, Secreting Particles
Affiliation: Tulane University
Abstract: Motivated by autophoretic droplet swimmers that move in response to a self-produced chemical gradient, here we examine the collective dynamics of individual motile agents using a simple reaction-diffusion system. The agents have an unlimited supply of a chemical, secrete it at a given rate, but are anti-chemotactic so move at a given speed in the direction of maximal decrease of this chemical. In both one- and two-dimensional periodic domains, we find intriguing long-time behavior of the system. Depending upon a non-dimensional parameter that involves secretion rate, agent velocity, domain size and diffusion, we find that the position of the agents either relax to regularly spaced arrays, approach these regular arrays with damped oscillation, or exhibit undamped, periodic trajectories. We examine the progression of particles that are initially seeded randomly, and we also examine the stability of the steady and periodic states.
Authors: Sang-Eun Lee (Tulane University), Ricardo Cortez (Tulane University), and Lisa Fauci (Tulane University)

Dananjani Madiwala Liyanage

Title: Multi-dimensional Nonparametric Goodness-of-Fit Tests Reduced to One-dimension via Ordering
Affiliation: Texas Tech University
Abstract: Non-parametric goodness-of-fit(GoF) tests are used to assess whether a sample of observations is consistent with a specific theoretical distribution when the underlying distribution is unknown or does not follow a specific parametric form. In the case of multidimensional data, traditional non-parametric GoF tests face limitations that arise from the definition of the cumulative distribution function (CDF) in higher dimensions. In this study, we propose ordered GoF tests for multi-dimensional testing. The main idea of this proposed ordered GoF tests is to reduce multi-dimensional data to one-dimensional data using an ordering function. We also propose directed and undirected versions of newly introduced

different versions of Neyman Smooth GoF tests for one-dimensional testing. The test statistic of directed and undirected GoF tests is based on orthonormal polynomial functions w.r.t the null distribution. We adapt these proposed directed and undirected GoF tests for multi-dimensional setting via ordering function. The performance of the proposed tests for both one dimensional and multi-dimensional testing is examined through a simulation study. The results of simulation show that proposed tests are powerful than traditional tests even for small sample sizes.
Authors: Dananjani Madiwala Liyanage (Texas Tech University), Alexandre Trindade (Texas Tech University) and Igor Volobouev (Texas Tech University)

Harold Anžej Margeta-Cacace

Title: A Numerical Comparison of Deep Ritz Networks and Physics-Informed Neural Networks for Modeling High-Frequency and Multiscale Differential Equations
Affiliation: Texas Tech University
Abstract: Neural networks have proven quite effective in the context of numerical solutions to differential equations, particularly through the use of physics-informed neural networks (PINNs). However, PINNs encounter significant challenges when modeling multiscale and high-frequency solutions, even with mitigating strategies like Fourier-feature mappings. Thus, alternative network architectures are needed. In this work, we numerically compare the performance of the one such architecture, the Deep Ritz Network (DRN), with that of the PINN for ODEs and PDEs whose solution is multiscale or high-frequency, and observe superior errors for the DRN in such cases. Additionally, we show how hard constraints and Fourier-features universally improve the suitability and fidelity of the eigenvectors of the neural tangent kernel (NTK) matrix, which in turn allows for faster and more accurate convergence.
Authors: Juntao Huang (Texas Tech University) and Harold Anžej Margeta-Cacace (Texas Tech University)

Austin Marstaller

Title: On Localization of the Fractional Discrete Nonlinear Schrödinger Equation
Affiliation: Southern Methodist University
Abstract: The continuum and discrete fractional nonlinear Schrödinger equations (fDNLS) represent new models in nonlinear wave phenomena with unique properties. In this paper, we focus on various aspects of localization associated to fDNLS featuring modulational instability, asymptotic construction of onsite and offsite solutions, and the role of Peierls-Nabarro barrier. In particular, the localized onsite and offsite solutions are constructed using the map approach. Under the long-range interaction characterized by the Lévy index $\alpha > 0$, the phase space of solutions is infinite-dimensional unlike that of the well-studied nearest-neighbor interaction. We show that an orbit corresponding to this spatial dynamics translates to an approximate solution that decays algebraically. We also show as $\alpha \to \infty$, the discrepancy between local and nonlocal dynamics becomes negligible on a compact time interval, but persists on a global time scale. Moreover it is shown that data of small mass scatter to free solutions under a sufficiently high nonlinearity, which proves the existence of strictly positive excitation threshold for ground state solutions to fDNLS.
Authors: Brian Choi (United State Military Academy: West Point) and Austin Marstaller (Southern Methodist University) and Alejandro Aceves (Southern Methodist University)

Mason A. McCallum

Title: Modeling Topological Insulators using a Discontinuous Galerkin Method and Complete Radiation Boundary Conditions
Affiliation: Southern Methodist University
Abstract: Topological Insulators are a phase of matter which supports waves that robustly localize near the material interface. The author of this work aims to model such waves using a Discontinuous Galerkin Method and a complete radiation boundary condition. Current models disregard the bulk of the material thus truncating the evanescent waves. Here we aim to make a more precise discretization of the model.
Authors: Mason A. McCallum (Southern Methodist University)

Tiffany McHenry

Title: Mathematical Modeling Tumor Growth Using Dose-Response Curves
Affiliation: Texas Christian University
Abstract: Mathematical modeling of cancer is growing in its applications since it demonstrates various cancer growth mechanisms. It does this by providing quantitative predictions that can be verified. Typically, parameters for cancer growth models are estimated using a cancer growth curve (volume versus time graph). However, currently, data for cancer growth curves are not as available as data for dose-response curves. In this work, we are proposing an alternative method for estimating model parameters from the use of dose-response curves. To do this we will introduce an analytical and numerical modeling approach to approximate each of the parameters in seven different tumor growth ordinary differential equations (ODEs). We will use recently published work (Juan et al.,2015) where they measured a dose-response curve. By using this method of cancer treatment modeling, we consider the impact of drug efficacy parameters on the model. Furthermore, we develop a more consistent picture of how each of the ODEs impacts This will allow for the creation of more consistent predictions for personalized cancer treatment.
Authors: Hana Dobrovolny (Texas Christian University), Dustin Johnson (Texas Christian University), Amrei Grund (University of Heidelberg)

Gavin McIntosh

Title: Modeling Supraventricular Tachycardia Using Dynamic Computer-Generated Left Atrium
Affiliation: Tarleton State University
Abstract: Supraventricular Tachycardia (SVT) occurs when the heart's atria beat rapidly or irregularly compared to the ventricles. Although not immediately fatal, this disharmony contributes to strokes, heart attacks, and heart failure. Catheter ablation is the primary treatment, wherein an electrophysiologist creates a 3D heart map, guiding a catheter to burn aberrant tissue with RF energy. Despite advances, gaps persist in understanding SVT triggers and optimal ablation sites, especially in cases like atrial fibrillation (AF). To address these gaps, our team has created a model of the left atrium that beats in real time and is adjustable down to the level of individual muscles. Users can implement ablation strategies on our digital twin to quickly gain insights outside of the operating room. Patient data can be imported directly from a CT scan and electro-cardial mapping. This approach accelerates SVT comprehension without endangering lives. Our work holds life-saving potential that could revolutionize cardiac care.
Authors: Gavin McIntosh (Tarleton State University) and Avery Campbell (Tarleton State University) and Melanie Little (Tarleton State University) and Bryant Wyatt (Tarleton State University)

Bailey Meche

Title: DiseaseNet: A transfer learning approach to noncommunicable disease classification
Affiliation: University of Louisiana at Lafayette
Abstract: As noncommunicable diseases (NCDs) pose a significant global health burden, identifying effective diagnostic and predictive markers for these diseases is of paramount importance. Epigenetic modifications, such as DNA methylation, have emerged as potential indicators for NCDs. These have previously been exploited in other contexts within the framework of neural network models that capture complex relationships within the data. Applications of neural networks have led to significant breakthroughs in various biological or biomedical fields but these have not yet been effectively applied to NCD modeling. This is, in part, due to limited datasets that are not amenable to building of robust neural network models. In this work, we leveraged a neural network trained on one class of NCDs, cancer, as the basis for a transfer learning approach to non-cancer NCD modeling. Our results demonstrate promising performance of the model in predicting three NCDs, namely, arthritis, asthma, and schizophrenia, for the respective blood samples, with an overall accuracy (f-measure) of 94%. Furthermore, a concept-based explanation method called Testing with Concept Activation Vectors (TCAV) was used to investigate the importance of the sample sources and understand how future training datasets for multiple NCD models may be improved. Our findings highlight the effectiveness of transfer learning in developing accurate diagnostic and predictive models for NCDs.
Authors: Steven Gore (University of North Texas), Bailey Meche (University of Louisiana at Lafayette), Benjamin Ginnett (Eastern Arizona College), Kelly Zhou (University of North Texas), Rajeev K. Azad (University of North Texas)

Preskella Mrad

Title: Model Reduction for Bayesian Inversion
Affiliation: University of Texas at Dallas
Abstract: Inverse problems can be formulated in a Bayesian framework to assess the uncertainty of the predicted models. In recent decades, Markov chain Monte Carlo has grown in popularity as a powerful tool for Bayesian inversion. Many practitioners of MCMC implicitly assume the convergence of the posterior distributions. We emphasize that results from chains which have not been shown to converge should not be relied upon in uncertainty quantification or decision making. Though a number of convergence diagnostics have been developed, their usefulness has only been demonstrated for low dimensional problems. Realistic geophysical problems are unavoidably high dimensional, with models often reaching dimensions in the tens of thousands. We propose pairing MCMC with model reduction techniques, in particular the discrete cosine transform reparametrization to obtain a posterior distribution over reduced models whose convergence can be demonstrated.
Authors: Preskella Mrad (University of Texas at Dallas) and Susan E. Minkoff (University of Texas at Dallas)

Austin Nelson

Title: Preconditioning of Tensor Train Methods with Application to Radiation Transport
Affiliation: Texas Tech University

Abstract: Tensor train-based methods for numerically solving PDEs have gained traction recently due to their efficient data compression. In particular, efforts have been made to apply tensor trains to solving the thermal radiation transport equation and other high dimensional PDEs. While these methods have provided exemplary memory compression for such problems, the iterative methods themselves are not as efficient as they may be. Specifically, the tensor-train iterative methods in available libraries lack the preconditioning needed for faster runtime and greater accuracy . We propose the construction of effective preconditioners for solving the thermal radiation transport equation numerically in the tensor train format. Our work will then be implemented in the tensor train C++ codebase BoBa authored by Lawrence Livermore National Lab.
Authors: Austin Nelson (Texas Tech University), Victoria Howle (Texas Tech University), and Longxiu Huang (Michigan State University)

Alina Oktyabrskaya

Title: Using resonance to create low gain threshold
Affiliation: Louisiana State University
Abstract: The phenomenon of resonance in gain materials is broadly used in applications of electromagnetics and optics. Low gain threshold allows one to achieve the lasing effect with minimal input energy. We present a model for the full Maxwell equations in a thick planar waveguide that exploits Fano resonance to achieve ultra-low gain threshold. We prove a relation between the gain and the sharpness of the resonance, which is related to the coupling of propagating modes and a bound state.
Authors: Alina Oktyabrskaya (Louisiana State University) and Stephen Shipman (Louisiana State University)

Monika Pandey

Title: Quantification of frog eggs in petridish using CNN
Affiliation: Louisiana State University, Baton Rouge
Abstract: There is a notable absence of highly precise machine learning tools to predict the quantity of frog eggs within a densely populated petridish. In response to that, we developed a convolutional neural network (CNN) based supervised machine learning tool for the precise estimation of frog egg numbers. Our approach involved the creation of curated datasets comprising 180 images of petridish containing frog eggs, which were then annotated to produce masked images for training purposes. Notably, our classifier exhibited an impressive average accuracy rate of 90% on both the training and testing sets. We validated performance of our model on a densely populated petridish containing 2006 frog eggs. The model achieved an accuracy of 99.3%, correctly identifying 1992 out of the 2006 eggs. This exceptional performance underscores the model's capability to accurately discern the number of frog eggs in complex environments.
Authors: Monika Pandey(Louisiana State University, Baton Rouge) and Peter Wolenski (Louisiana State University, Baton Rouge)

David Pecoraro

Title: Approximation of the Compressible Euler Equations in the Low Mach Limit

Affiliation: Texas A&M University
Abstract: We propose a second order, invariant domain preserving approximation of the compressible Euler equations in the low Mach limit. This approximation gives rise to an explicit, consistent, and conservative scheme that satisfies the necessary entropy inequalities to have physically relevant solutions.
Authors: Jean-Luc Guermond (Texas A&M University), Matthias Maier (Texas A&M University), and David Pecoraro (Texas A&M University)

Daniela A. Florez Pineda

Title: Assessing the Risk of Dengue Outbreaks Across Continental Biomes in Brazil
Affiliation: Tulane University
Abstract: Dengue is a mosquito-borne disease that causes an estimate of 390 million new infections every year and has been historically limited to tropical regions. Current evidence suggests that already occurring climate change is altering the distribution of mosquito-borne diseases. These changes will strain the global public health system by introducing old diseases into naïve populations. Consequently, it is relevant to characterize the behavior of dengue transmission in the context of climate change. The central challenge of understanding the relation between dengue incidence and temperature variation relies on the non-linear trend it exhibits, along with the complex interactions among environmental variables and the biology in the spread of this disease. To better capture the dynamics of temperature-dependent dengue risk, we propose a SEIR-type model to analyze its behavior across tropical eco-zones. This model integrates statistical methodologies to infer the time dependence on the mosquito biting rate, carrying capacity, and growth rates. In addition, temperature dependent mosquito-life traits are included as distributional forms into our mechanistic approach. Because of their well-differentiated ecological diversity, we have selected Brazil's continental biomes to validate our model output and illustrate better the effects of spatial and temporal temperature heterogeneity on dengue dynamics.
Authors: Daniela A. Florez Pineda (Tulane University), Ethan Romero-Severson (Los Alamos National Laboratory), Carrie Manore (Los Alamos National Laboratory), Kaitlyn Martinez (Los Alamos National Laboratory), Caroline Franco (University of Aberdeen (UK)

Ray Qu

Title: Entropy stable reduced order modeling of nonlinear conservation laws using discontinuous Galerkin methods
Affiliation: Rice University
Abstract: We generalize the construction of entropy stable reduced order models (ROMs) for nonlinear conservation laws from finite volume methods to high order discontinuous Galerkin (DG) methods. This generalization preserves entropy stability while simplifying the hyper-reduction step by utilizing the gappy proper orthogonal decomposition (POD) and Caratheodory pruning for the hyper-reduction of boundary conditions.
Authors: Ray Qu (Rice University) and Jesse Chan (Rice University)

Charu Rajapaksha

Title: An In-depth Examination of Suicide Rates in the USA Across Time, Race, Age, and Socio-economic Contexts.

Affiliation: Texas Tech University
Abstract: Suicide, a profound societal concern, has witnessed fluctuating trends in the USA over several decades, profoundly impacting families, communities, and the nation's socio-cultural fabric. It is important to take a deep look at their patterns for effective prevention, as they are complex with diverse factors ranging from demographics to social and economic conditions. This comprehensive study delves into the intricate determinants of suicide rates in the USA from 1980 to 2021. The findings of the first surveys indicate a concerning increase in 21st-century rates, with men consistently registering higher rates than women. But there are growing trends in both genders. However, both genders exhibit rising trends. Diving deeper into racial categories, 'Not Hispanic or Latino(Black or African American)' consistently reported high rates, followed closely by 'Not Hispanic or Latino(White)'. Analysis by age and ethnicity pinpoints particularly vulnerable demographics, like the 'Not Hispanic or Latino (American Indian or Alaska Native)' among the young, and the older 'Not Hispanic or Latino(White)' community. Surprisingly, the states' data highlight Montana and Wyoming as areas that are at high risk. The study also establishes socio-economic indicators, such as old-age and young-age dependency ratios, as pivotal determinants of suicide trends. As elderly proportions rise, suicide rates tend to increase, influenced by mental health challenges, economic stressors, and societal isolation. On the contrary, a more youthful population with potential drivers such as economic optimism, strong connections in society and increasing awareness about psychological health is having its protective effect. Policymakers are urged to heed these findings to craft tailored interventions addressing the multifaceted nature of societal influences on mental health and suicide rates.
Authors: Charu Rajapaksha(Texas Tech University)

Aman Rani

Title: Efficient Solution for Fully Implicit Runge-Kutta Methods for Hyperbolic PDEs
Affiliation: Texas Tech University
Abstract: We focus on implicit Runge-Kutta (IRK) time stepping of time-dependent hyperbolic PDEs. IRK time stepping of PDEs leads to linear systems with a Kronecker product structure involving the Butcher table and the mass and stiffness matrices. The system arising from IRK-time stepping applied to the wave equation is highly ill-conditioned but has a block structure we exploit. If N is the number of degrees of freedom for the discretization of the PDE, then the resulting matrix after IRK-time stepping is a block $s \times s$ matrix where each block is of size $2N \times 2N$. Traditionally, preconditioning techniques are used for solving these systems, but we reformulated the large $2Ns \times 2Ns$ block structured linear system as a Sylvester matrix equation. That leads to solving s block systems of order $2N \times 2N$ which are solved using 2 AMG V-cycles. As we increase the Runge-Kutta stages and refine the mesh, our method is twice as fast compared to other existing methods and takes fewer AMG V-cycles. It also reduces the time complexity from $O(s^2N)$ to $O(sN)$.
Authors: Aman Rani (Texas Tech University), Pieter Ghysels (Lawrence Berkeley National Laboratory), Victoria Howle (Texas Tech University) and Katharine Long (Texas Tech University)

Richa Rawat

Title: Dimensionality Reduction using Clustering Guided t-SNE
Affiliation: University of Texas at Dallas
Abstract: This paper aims to present a novel dimension reduction technique that reveals the local and global structure of the high-dimensional data when embedded in a low-dimensional (2 or more) space. The

state-of-the-art nonlinear dimension reduction technique, t-distributed stochastic neighbor embedding (t-SNE), is used extensively to visualize and cluster high dimensional data. However, t-SNE focuses primarily on preserving distance between similar points, resulting in a loss of global structure, and the visualization in each trial run of t-SNE results in a different arrangement of the clusters in low-dimensional space. The proposed Clustering Guided t-SNE technique combines t-SNE with a k-means clustering algorithm to preserve nearby and distant neighborhoods in the dataset. The performance of Clustering Guided t-SNE is measured using scalar quality metrics which measure the preservation of local structures and global structures of the data. The proposed method shows better performance than t-SNE in visualizing two-dimensional synthetic Gaussian data and high-dimensional benchmark datasets used in data science and biological science.
Authors: Richa Rawat (University of Texas at Dallas) and Yan Cao (University of Texas at Dallas)

Rifat Rejuan

Title: A cell-based approach to study the dynamics of CTCs within a microfluidic capture device
Affiliation: Department of Mathematics and Statistics, Texas Tech University, TX
Abstract: Circulating tumor cells (CTCs) are cancer cells that detach from their primary location and enter the bloodstream. Which has the ability to infect other healthy parts of the body. This process is called metastasis, the main reason that shortens the lifespan of a cancer patient. Although CTCs can be found in the early stage of cancer, it is very hard to detect because of the rarity of CTC in whole blood. In recent years, research on microfluidic devices (Microchips) for capturing CTCs appears promising. One such microchip with a hyperuniform (HU) structure that already developed can isolate and selectively separate CTCs. Hyperuniform disordered structures appear locally completely random but globally a uniform distribution. We studied the interaction between CTCs and blood flow within a microfluidic device, distinguished by its hyperuniform structure, which was simulated using the lattice Boltzmann method (LBM) and immersed boundary method (IBM). To examine the intricate dynamics of CTCs, we employed a coarse-grained spectrin-link membrane model. Through analysis of CTC trajectories and the forces acting on them, we systematically assessed multiple microfluidic channel configurations, with the aim of identifying the most efficient hyperuniform structure for the microfluidic device, capable of effectively capturing various CTC types.
Authors: Rifat Rejuan, Yifan Wang (Texas Tech University)

Abdullah Saifee

Title: Investigating the Impact of Mechanosensation on Retronasal Olfaction
Affiliation: Southern Methodist University
Abstract: Retronasal olfaction, smell that comes from the back of the nasal cavity by exhaling accounts for partial flavor perception, just like orthonasal olfaction, which is the smell perceived by inhalation. But unlike the orthonasal olfaction, retronasal olfaction is still little studied and as a result, rather poorly understood. There have been studies which indicate that even for identical odors, the brain activation that occur are different between the two types of olfaction (Blankenship et al. 2019). Prior experiments show that synaptic inputs to the olfactory bulb (OB) from the nose are different for ortho- and retronasal olfaction in rats (Zhao et al. 2006), (Small et al. 2005), (Samuelsen and Fontanini 2017). How the nasal epithelium is stimulated for the two types of olfaction, is still to be identified. So the effects of reversing the direction of airflow through the nasal cavity need to be studied. Recent studies have performed in vivo multi-electrode recordings of the OB in rats. They have shown that there are statistically significant

differences between ortho and retro stimulation. At the application of odor, there is a faster rise followed by a faster decay in the firing rate during orthonasal stimulation. On the contrary, there is a comparatively slower rise followed by a slower decay during retronasal stimulation (Craft et al. 2021). In multiple 30 seconds trials with two different odorants, it is found that depending on which odorant is applied, there is selectivity among the OB mitral cells to ortho and retro stimulation (Craft et al. 2021). In other words, for a particular odor like 1-hexanol, some cells show more firing activities during ortho mode whereas for another odor like ethyl butyrate, some cells show more firing activities during retro mode of breathing. Interestingly, since in nature 1-hexanol is an aromatic compound in grass and ethyl butyrate is found in some fruits, this implies there is a phase selectivity of the OB cells that depends on whether the odorant source has an impact on the animal. Our hypothesis is that at the sensory periphery, the retro and ortho nasal stimuli produce distinct spatiotemporal patterns of mechanosensory excitation of olfactory receptor neurons. Experiments show that mechanical forces by air flow can lead to robust neural response in olfactory bulb (Iwata et al. 2017). So it is likely that the airflow patterns will be quite different for retronasal flow compared to orthonasal flow, leading to different mechanical forces on olfactory receptor neurons (ORNs) and different input to olfactory bulb (OB). The aim here is to test this with fluid dynamics simulations in experimentally obtained, animal-specific nasal cavity geometries. To that end, we have run multiple fluid simulations. First we ran simulations on a single chamber of an idealized human nasal cavity and tested the validity by comparing them with previous studies using similar cavity models. We then ran simulations on human anatomical models which provided us with some insights regarding our hypothesis, one of them being that the phase selectivity could be animal specific.
Authors: Abdullah Saifee (Southern Methodist University), Andrea Barreiro (Southern Methodist University), Cheng Ly (Virginia Commonwealth University), Woodrow Shew (University of Arkansas)

Jeremy Shahan

Title: Shape Optimization with an Unfitted Finite Element Method
Affiliation: Louisiana State University
Abstract: We present a formulation of a PDE-constrained shape optimization problem that uses an unfitted finite element method (FEM). The geometry is represented (and optimized) using a level set approach and we consider objective functionals that are defined over bulk domains. For a discrete objective functional (i.e. one defined in the unfitted FEM framework), we show that the exact shape derivative can be computed rather easily. In other words, one gains the benefits of both the optimize-then-discretize and discretize-then-optimize approaches. We illustrate the method on a simple model (geometric) problem with known exact solution, as well as shape optimization of structural designs. We also give some discussion on convergence of minimizers. This is joint work with Shawn W. Walker (walker@math.lsu.edu, LSU)
Authors: Shawn Walker (Louisiana State University) and Jeremy Shahan (Louisiana State University)

Arshia Singhal

Title: A Discontinuous Galerkin Scheme for Closed-Loop Solute Transport in Blood Vessels
Affiliation: Rice University
Abstract: Hypoplastic left heart syndrome (HLHS) is a congenital heart disease that accounts for 2-3% of congenital heart diseases in the United States and 40% of all neonatal cardiac deaths. HLHS causes oxygenated blood to mix with deoxygenated blood, resulting in death. This raises a critical need to

accurately model the transport of oxygen in blood vessels and organs throughout the human body to improve outcomes in patients with HLHS. Previously, numerical reduced models have been created to solve for blood flow and concentration of one solute. These models reduce the dimensions of the vessels and organs to improve computational efficiency. My work extends the models from open network of blood vessels to closed loops. Appropriate transmissibility conditions at each vessel junction and organ bed are constructed, that are based on balance laws. The class of interior penalty discontinuous Galerkin methods is used for the discretization of the models.
Authors: Arshia Singhal (Rice University)

Anthony Stefan

Title: New perspectives and representations for Dirichlet-to-Neumann maps and effective conductivity in electrical network theory
Affiliation: Florida Institute of Technology
Abstract: This poster displays how the mathematical framework in the theory of composites can be extended to electrical network theory on finite linear graphs for the Dirichlet-to-Neumann (DtN) map and effective conductivity. For the DtN map, we give a new representation that is based on the discrete Hodge decomposition for the Dirichlet problem and the Z-problem in the abstract theory of composites with its associated effective operator. For the effective conductivity, we also give a representation theorem that is a completely new result based on a generalized Hodge decomposition, which is used to show that the effective conductivity is an effective operator of the Z-problem associated with this Hodge decomposition. We conclude by connecting this work with our ongoing research project on Bessmertnyĭ realizability theory showing, under certain natural hypotheses on the network conductivity, that the DtN map and the effective conductivity both have Bessmertnyĭ realizations. This work is based off of a recent publication K. Beard, A. Stefan, R. Viator, and A. Welters. Effective operators and their variational principles for discrete electrical network problems. J. Math. Phys. 28 July 2023; 64 (7): 073501. DOI:10.1063/5.0130429.
Authors: Anthony Stefan (Florida Institute of Technology) and Aaron Welters (Florida Institute of Technology)

John Steinman

Title: Impact of Representation of Collocation Methods on Dynamic Optimization Problems
Affiliation: Department of Computational Applied Mathematics and Operations Research, Rice University
Abstract: Optimization problems governed by ordinary differential equations (ODEs) are often solved using collocation, where the original infinite dimensional problem is discretized into a nonlinear programming problem (NLP) by approximating the states (and if present controls) using piecewise polynomials and then enforcing the ODE at nodes obtained from a Gaussian quadrature. The choice of these collocation nodes determines the approximation properties of the collocation method. However, the numerical properties of the collocation method depend on its representation. This representation is determined by whether the ODE is written in differential or integral form, and by the polynomial basis used to represent the state approximation. While different collocation representations have been used in isolation, to our knowledge there has been no systematic discussion of these representations and their impact on the numerical solution, particularly when a large number of collocation nodes is used. Here we consider three collocation representations corresponding to the classical differential formulation and two integral formulations. The latter two are Runge-Kutta methods. We show that the transcribed NLPs arising from each representation are equivalent up to scaling of variables and constraints, which is important for

co-state estimation. This scaling also impacts the conditioning of linear systems that arise during the solution of the NLP. A numerical parameter estimation example is considered to assess the conditioning of the Newton systems given by the Lagrange-Newton SQP method applied to the transcribed NLPs.
Authors: John Steinman (Rice University), Anwar Khaddaj (Rice University), and Matthias Heinkenschloss (Rice University)

Marc de Vernon

Title: Adaptive time stepping methods for Discontinuous Galerkin schemes applied to multiscale, long-time evolution equations in periodic media.
Affiliation: Southern Methodist University
Abstract: Multi-scale equations are ubiquitous in physical models. Requiring a fine mesh to resolve the fine-scale features. Running this over long periods can be very computationally expensive. Many approaches focus on dimensionality reduction but exclude adaptive time stepping in the DG scheme. I investigate an adaptive time stepper for a reduced order DG scheme.
Authors: Marc de Vernon (Southern Methodist University)

Jorge Villalobos

Title: Stable defect states in the continuous spectrum of bilayer graphene with magnetic field
Affiliation: Louisiana State University
Abstract: In a tight-binding model of AA-stacked bilayer graphene, a bound defect state within the region of continuous spectrum can exist stably with respect to variations in the strength of a perpendicular magnetic field. This is accomplished by creating a defect that is compatible with the interlayer coupling, thereby shielding the bound state from the effects of the continuous spectrum, which varies erratically in a pattern known as the Hofstadter butterfly.
Authors: Stephen P. Shipman (Louisiana State University) and Jorge Villalobos (Louisiana State University)

Yimo Wang

Title: DG-Based PINNS for Elliptic Problems
Affiliation: Rice University
Abstract: Many scientific problems are characterized by partial differential equations (PDEs). Existing numerical methods to solve PDEs may be computationally expensive, resulting in a need for less costly methods. In this work, we combine neural networks with classical numerical discretizations to mitigate some of these costs. We focus on the Poisson problem and present several numerical examples that show the robustness of the neural-based method.
Authors: Yimo Wang (Rice University), Adrian Celaya (Rice University), and Beatrice Riviere (Rice University)

Zachary Watson

Title: Modeling Dust Crystals in Complex Plasmas using GPU Acceleration

Affiliation: Tarleton State University
Abstract: A complex plasma is a plasma that contains nanometer to micron-sized dust. Dust accumulates more electrons than ions, causing it to become negatively charged. This phenomenon reverberates across various domains, including self-assembly of nanostructures, dust mitigation in semiconductor fabrication, and control of dust in fusion reactors. Experimentalists confine charged dust in electric fields, illuminate it with lasers, and track its motion using high-speed cameras. These setups incur substantial costs, often exceeding hundreds of thousands of dollars, and demand extensive labor and time. To address these challenges, computational models are increasingly guiding research. Here, we present our dynamic modeling innovation, utilizing NVIDIA GPUs, to predict intricate dust crystal formations within a complex plasma. Employing simulations to guide and validate laboratory experiments is reshaping our understanding of complex plasma, driving interdisciplinary breakthroughs.
Authors: Zachary Watson (Tarleton State University) and Samuel Garcia-Rodriguez (Tarleton State University) and Jorge Martinez (Baylor University) and Bryant Wyatt (Tarleton State University)

Binadie Wickramasinghe

Title: Ovarian Cancer Prediction using Logistic Regression and Decision Trees
Affiliation: Bridgeland High School
Abstract: Ovarian cancer is considered the fifth most common cancer type among females in the US. Furthermore, ovarian cancer accounts for 25% of all gynecologic cancers, and usually, this cancer is diagnosed at a late stage. A patient can live over five years if ovarian cancer is diagnosed early. Therefore, early diagnosis of ovarian cancer is essential. This study aims to predict ovarian cancer patients using biomarkers and several data-classifying models using Logistic Regression and Decision Tree (DT) approaches. Furthermore, we compare the performances of each model using various model performance indicators, such as accuracy, Precision, and recall values. Based on the findings, the DT algorithm shows 78% Accuracy, 81% Recall value, and 78% Precision for the testing data. In the meantime, LR shows an accuracy of 86%, Recall of 98%, and 80% Precision. Recall value is more critical than other indicators to identify ovarian cancer. Therefore, the Logistic Regression performs better than the Decision Tree approach to predict ovarian cancer.
Authors: Binadie Wickramasinghe (Bridgeland High School, Cypress, TX) and Gloria Regisford (Prairie View A&M University)

Indika Wickramasinghe

Title: Elementary Students' Literacy Skills Prediction: Bagging Approach
Affiliation: Prairie View A&M University
Abstract: Recognizing students' literacy skills at an early stage is very important for parents and school administrators. This study reports the findings of a study to predict elementary students' achieving the benchmark of the literacy level using Bagging techniques. Using data collected from first- and second-grade students regarding their academic-related and other information, we used several bagging algorithms to predict their literacy skills. Students' literacy levels are quantified using their Dynamic Indicators of Basic Early Literacy Skills (DIBELS) score. Based on the experimental findings, the hyper-parameterized Random Forest model showed significantly better performances compared to its counterparts, achieving a recall value of 81% to identify a student at the risk of meeting the benchmark level.
Authors: Indika Wickramasinghe (Prairie View A&M University) and Regina Aragon (Eastern New Mexico University)

Dilong Zhou

Title: Multiscale Mixed Methods with Improved Accuracy: The Role of Overlapping and Smoothing
Affiliation: University of Texas at Dallas
Abstract: Multiscale mixed methods based on non-overlapping domain decompositions have been carefully studied in recent years. Linear solvers for porous media flow problems based on these methods are naturally parallelizable in multi-core computers and can handle efficiently the solution of large problems in very heterogeneous formations of interest to the industry. Efficiency in the numerical solutions is dictated by the choice of interface spaces that are selected: the smaller the dimension of these spaces, the better, in the sense that fewer multiscale basis functions need to be computed and smaller interface linear systems need to be solved. Thus, in the solution of large computational problems, it is desirable to work with piecewise constant or linear polynomials. In these cases, it is well known that the flux accuracy, when computed in terms of fine grid solutions, is of the order of 10-1. In this work, we focus on the development of a practical, efficient, and accurate solver for large problems. We consider subdomains with small overlapping regions, and we introduce the concept of a smoothing step, to handle small-scale errors in the multiscale solution. Moreover, we introduce novel informed spaces for the calculation of multiscale basis functions. Several numerical studies are presented to illustrate the good properties of the new solver. We consider initially a problem with an analytical solution followed by a careful study of two-dimensional solutions of several layers of the permeability field of the SPE 10 project.
Authors: Dilong Zhou (University of Texas at Dallas) and Luis Felipe Feres Pereira(thesis advisor) (University of Texas at Dallas)