2026 Texas Differential Equations Conference

March 7, 2026 • San Antonio, Texas

Department of Mathematics, University of Texas at San Antonio

https://txpde2026.github.io/

Book of Abstracts

About the Conference

The Texas Differential Equations Conference is an annual event that brings together researchers working on differential equations and related topics. It was first organized by Professors Charles Radin and Ralph Showalter at the University of Texas at Austin in 1978. The conference upholds a strong democratic tradition: there are **no principal speakers**, all talks are allocated the **same length of time**, and there is **no registration fee**. The intent is to encourage participation by young faculty and graduate students.

Venue & Location

University of Texas at San Antonio, Main Campus, 1 UTSA Circle, San Antonio, TX 78249

Biosciences Building (BSB) • Room 1: 3.03.02, Loeffler Room • Room 2: 3.03.10, Board Room

Organizing Committee

Erika Tatiana Camacho • Fengxin Chen • Zhuolin Qu • Stephen Wirkus

Sponsor

This conference is made possible by the generous support of the **Department of Mathematics** and the **Office for Research and Innovation** at the University of Texas at San Antonio.

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The Diffusive Lotka-Volterra Competition Model in Fragmented Patches: Coexistence

We study a diffusive Lotka Volterra competition model where two species are competiting in a habitat with certain strength of competitions (b1, b2). In the model, we incorporate a positive parameter λ representing the measure of patch size. We also consider the hostilities of exterior domain and analyze positive solutions of the model as the parameters vary

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Huston-Tillotson University

Global Existence of Solutions for a Class of Nonlocal Reaction-Diffusion Systems and Their Diffusive Limit

In this work, we study the global existence of solutions of a system of nonlocal reaction-diffusion system of arbitrary m components in $n \in \mathbb{N}$ dimension. The reaction function follows quasi-positivity and *intermediate sum inequality* mass control (both time dependent and independent case). We develop L^p energy type functional to establish the uniform boundedness of solutions independent of the kernel of nonlocal operator for this system. We then develop a mixed type of m component nonlocal reaction-diffusion system using both local and nonlocal operator and establish it's global existence and uniform boundedness of solutions using duality arguments. Then we prove the convergence of nonlocal operator to local operator. At last, we approximate the solutions of both local and nonlocal reaction-diffusion systems and verify their convergence from nonlocal to local numerically. We also simulate the mixed type nonlocal reaction-diffusion system to show the difference of its solutions with our system visually.

Dambaru Bhatta dambaru.bhatta@utrgv.edu
UTRGV

Crack-Tip Field Behavior in a Transversely Isotropic Strain-Limiting Thermoelastic Medium

We investigate crack-tip stress–strain fields in a transversely isotropic thermoelastic solid governed by a nonlinear strain-limiting constitutive law. The model admits high stress levels while maintaining bounded strains, thereby eliminating the classical crack-tip strain singularities predicted by linear elastic fracture mechanics (LEFM). The coupled temperature–displacement equations are solved numerically using a Galerkin finite element method, and the resulting stress and strain fields are obtained through post-processing. Numerical results illustrate the distributions of temperature, stress, and strain.

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Texas A&M University-Texarkana

Quenching for Multi-Dimensional Semilinear Parabolic Problems with a Localized Source

In this talk, we present results on the quenching set for a multidimensional semilinear parabolic problem posed on a ball with homogeneous Dirichlet boundary conditions. The source term of this problem is a nonlinear localized function. This function tends to infinity when the solution u approaches a finite number. This mathematical model illustrates a nonlinear reaction of a dynamical system occurring at a single location. Our main result is to prove that u quenches at a single point only and the blow-up set the time derivative of u is the whole domain.

Fengxin Chen Fengxin.chen@utsa.edu
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Nonexistence of Time Almost-Periodic Solutions of Nonlocal Evolution Equations

The main concern is the existence of non-trivial time almost-periodic solutions to nonlocal evolution equations

$$u_t - Du_{xx} - F(u, J_1 * s^1(u), \cdots, J_n * s^n(u)) = 0$$

for all $x \in \mathbb{R}$ and $t \in \mathbb{R}^+$. Here $D \geq 0$ is a constant, $J * v(x,t) = \int_{\mathbb{R}} J(x-y)v(y,t)dy$ is spatial convolution, the kernels J_i are of class $C^1(\mathbb{R})$ and nonnegative, and s^i are smooth functions, $i = 1, 2, \cdots, n$. Using the energy estimates, we prove that there exists no non-trivial time almost-periodic solution for $N = 1, 2$.

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Synthesizing Artistic Rendering with Scientific Rendering by Applying the Modal Analysis Method of Animal Shapes to Film Production

In this talk, we use the PDEs in continuum mechanics to compute and visualize eigenmodes of motion of animals. We then build motion sequences by mixing modes of motion of animals as a science-based way to make motion pictures. This is a way of scientific-rendering for film production. This can be further enhanced by artistic rendering using the video or movie-making software Blender. Short videos of a T-Rex dinosaur walking will be played at the talk.

Jesus Cruz jesus_cruz4@baylor.edu

Baylor University

Ill-Posed Problems for Scalar Operators in the Plane

In the 1950's, A. Bitsadze discovered that the Dirichlet problem for the square of the Cauchy–Riemann operator is ill-posed in the unit disk, a striking and unexpected phenomenon that I. Gelfand attributed to the multiplicity of its characteristic roots. In this work, we revisit this classical problem and show that the true source of the pathology lies elsewhere. Based on structural analysis, we provide a complete classification of all scalar complex operators in the plane that exhibit such ill-posed behavior. This is joint work with Dorina Mitrea and Marius Mitrea.

Baofeng Feng baofeng.feng@utrgv.edu

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Integrable Discretizations of the Massive-Thirring Model

In this talk, we first show the connection of the massive-Thirring (MT) model with the discreteKadomtsev-Petviashvili (dKP) hierarchy. Based on this finding, we can construct dark, breather and rogue wave solutions to the MT model. Further, we propose semi- and fully discrete analogues of the MT model and construct their multi-soliton solutions.

Zhaosheng Feng zhaosheng.feng@utrgv.edu

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A Parabolic System for Bacterial Colony Dynamics

In this work, we introduce a nonlinear parabolic system with dispersion to describe bacterial aggregation dynamics. In contrast to the corresponding model without dispersion, the inclusion of dispersion permits the propagation of bacterial clusters, indicating that dispersion can act as a regulatory mechanism for bacterial colony behavior. An analytical expression for the traveling-wave solution is derived by explicitly accounting for the dispersion coefficient. Numerical simulations further demonstrate that an initially random bacterial concentration evolves into a periodic wave pattern, which subsequently transitions into a stationary solitary wave in the absence of dispersion.

Anahit Galstyan anahit.galstyan@utrgv.edu
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The Solutions of the Semilinear Dirac Equation in the Curved Spacetime

In this talk we study solutions of the semilinear Dirac equation in the curved spacetime of the Friedmann-Lemaitre-Robertson-Walker (FLRW) models of cosmology. We describe the relationship between the mass term, scale factor, nonlinear term, and initial function, which provides a global in time existence or an estimate on the lifespan of the solution of the Dirac equation in the expanding universe.

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Hemodynamic Consequences of Medial Arterial Calcification: Interplay Between Tissue Stiffening and Peripheral Resistance

Medial arterial calcification, commonly associated with ageing, diabetes, and chronic kidney disease, alters arterial mechanics and contributes to chronic limb-threatening ischemia. Using a one-dimensional hemodynamic model with coupled fluid-solid partial differential equations, we examine how calcification and peripheral resistance jointly influence blood pressure and flow. Our results show that calcified arteries experience a greater systolic pressure drop than healthy vessels due to reduced pressurized lumen area, leading to decreased flow and peripheral perfusion. Although increased peripheral resistance can partially offset pressure loss, both factors ultimately impair tissue oxygenation. Positive remodeling mitigates pressure drop and improves outflow, whereas elevated systemic pressure increases both pressure gradients and flow. Overall, the increased impedance in calcified arteries arises primarily from reduced in vivo lumen area, with hemodynamic consequences strongly modulated by vascular resistance, geometry, and global pressure conditions.

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The Sperm Parasite Paradox

The Amazon molly (*Poecilia formosa*) is an all-female species that requires sperm from males of bisexual host species (*P. mexicana* and *P. latipinna*) to initiate embryo development, but the paternal genome is not incorporated into offspring. Unisexual females thereby drive the host toward feminization and extinction, eliminating their own sperm supply in the process. This is why *P. formosa* is characterized as a sperm parasite. Yet the species has persisted alongside its hosts for more than 100,000 years. We analyze a three-population model of this system under five stochastic formulations: a Random ODE (RODE), Itô Stochastic Differential Equations (SDEs), and Stratonovich SDEs, each with common or independent noise. The speed of male mate discrimination governs extinction versus coexistence across all formulations. However, only Itô noise is genuinely stabilizing: increasing noise amplitude shifts the Lyapunov exponent, protecting the host. Stratonovich noise is stability-neutral. The RODE dissipative threshold and the Itô Lyapunov threshold are analytically distinct and predict different stability boundaries. We discuss direct implications for how ecological modelers should choose and report their stochastic framework.

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Steklov Eigenproblems and Applications

Steklov eigenproblems on exterior regions and their applications will be discussed.

Joseph Iaia iaia@unt.edu
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Infinitely Many Solutions for (p, q)-Laplacian and $(p_1, p_2, \dots, p_n)$-Laplacian Problems

In this talk we prove existence of an infinite number of solutions to $\Delta_p u + \Delta_q u + K(x)f(u) = 0$ on exterior domains where $1 < q < p < N$ and $f(u)$ grows faster than u^{p-1}. We then generalize this result to find an infinite number of solutions of $\Delta_{p_1} u + \Delta_{p_2} u + \cdots + \Delta_{p_n} u + K(x)f(u) = 0$ on exterior domains where $1 < p_1 < p_2 < \cdots < p_n < N$ and with similar assumptions on f.

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Texas A&M University

Localization and Delocalization in Disorder Systems

In this talk, I will explore the quantum dynamics of the Schrodinger equation in disorder systems. These models exhibit strikingly different spectral behaviors, ranging from localization, where wave functions remain confined, to delocalization, where they fast transport occurs. Using classical toy models — including the Anderson model and the almost Mathieu operator- I will illustrate how these phenomena arise and how they shape our understanding of spectral transitions in complex quantum systems.

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Texas A&M University-Corpus Christi

Adaptive Finite Element Approximation and Convergence Analysis for Dynamic Phase-Field Fracture

This presentation introduces a convergent adaptive finite element method for simulating dynamic brittle fracture using a phase-field approach. By employing a staggered time-stepping scheme and a variational inequality, we circumvent explicit crack tracking while strictly enforcing damage irreversibility. Mesh adaptation is dynamically driven by a residual-based a posteriori estimator to efficiently resolve the fracture process zone. We will outline our rigorous convergence analysis and demonstrate the method's computational efficiency in capturing complex crack branching through 2D numerical benchmarks.

Cristian Meraz c.meraz.math@gmail.com
Texas State University

Existence of Weak and Mild Solutions for a Nonlocal Klausmeier Model

The Klausmeier model is a coupled system of partial differential equations governing surface water and plant biomass dynamics in semi-arid regions. The original model posits that plants disperse their seed according to classical diffusion. We opt for a nonlocal diffusive operator in alignment with ecological field data that validates long-range dispersive behaviors of plants and seeds. The equations feature homogeneous Dirichlet boundary conditions for the water equation and homogeneous nonlocal Dirichlet volume constraints for the plant biomass equation. The nonlocal operator involves convolution with a symmetric and spatially extended kernel possessing mild integrability and regularity properties. We employ the Galerkin method to establish the existence of small-time weak solutions. The key challenge comes from the nonlocal operator; it has domain a subspace of L^2 instead of H^1, precluding the use of Aubin's compactness theorem to prove the weak convergence of the nonlinear reaction terms. To overcome this, we modify the model to include two new equations for the spatial derivatives of the surface water and plant biomass variables. This procedure allows us to recover enough regularity to establish compactness and complete the proof. We then leverage semigroup theory and elliptic maximum principles for a proof of global solutions to our nonlocal model. In this setting, the spatial dimension is $n > 1$, and we assume that the domain $\Omega \subset \mathbb{R}^n$ has a smooth boundary. Assuming the initial data are non-negative and bounded in Ω, we prove that the component-wise weak solutions are also non-negative and bounded for all time, with uniform bounds that depend on the initial conditions and problem parameters.

Jose Morales Escalante jose.morales4@utsa.edu
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Quantum Stochastic Gradient Descent in Continuous-Time Limit by Wigner Form of Open Quantum Systems

The main ideas behind a research plan to use the Wigner formulation as a bridge between classical and quantum probabilistic algorithms are presented, focusing on a particular case: Quantum Stochastic Gradient Descent in its continuous- time limit based on the Wigner formulation of Open Quantum Systems. We present both theoretical and computational studies of its convergence for the benchmark case of a quadratic/harmonic potential function. Independence of the mixing time (convergence rate) as problem dimension increases is proved in our study.

Alex Sabey acsabey@gmail.com
San Jacinto College

Solutions to Mixed Non-Homogeneous Boundary Problems

We endeavor to show a systematic approach to solve non-homogeneous mixed boundary condition problems for Elliptic PDEs on Lipschitz domains with piece-wise smooth boundaries. This presentation will review results from Steklov eigenfunction problems and examine some of its subsets. Next, we will choose specific subsets of the Steklov problem to combine and solve the titled problem. The talk will conclude with comments about convergence properties of the solutions to the boundary conditions and within the interior.

Erwin Suazo erwin.suazo@utrgv.edu
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On Explicit Solutions for Systems of Partial Differential Equations with Variable Coefficients Through Riccati-Type Systems

In this collaboration with Dr. Jose Escorcia (EAFIT), our work focuses on the study of explicit solutions for generalized coupled reaction-diffusion, Burgers-type, and nonlinear Schr"odinger equations (NLS) systems with variable coefficients, including nonlinear models with variable coefficients such as the diffusive Lotka-Volterra model, the Gray-Scott model, the Burgers equations. Also, we show the existence of rogue wave and dark–bright soliton-like solutions for a generalized NLS system, provided the coefficients satisfy a Riccati type system. The equations' integrability (via the explicit formulation of the solutions) is accomplished by using similarity transformations and requiring that the coefficients fulfill a Riccati system. We present traveling wave-type solutions as well as solutions with more complex dynamics and relevant features, such as bending.

Long Teng lteng2@lsu.edu
Louisiana State University

Doubling Inequalities for Schrödinger Eigenfunctions with Power Growth Potentials

We study quantitative unique continuation for eigenfunctions of Schr"odinger operators with power growth potentials. Using rescaling arguments and Carleman estimates, we establish doubling inequalities with explicit dependence on the eigenvalue. These results extend classical doubling estimates from bounded to unbounded potentials. This is joint work with Zhiwei Wang and Jiuyi Zhu.

Amina Jean Thomas amina.thomas@my.utsa.edu

UT San Antonio

Modeling Infrastructure Vulnerability and Service Reliability in Rural Water Systems: A Differential Equation Framework Applied to Wilson County, Texas

Rural water systems across Texas face increasing pressure from aging infrastructure, fluctuating demand, groundwater depletion, and climate variability. Many small systems operate with limited financial reserves and technical capacity, making them especially vulnerable to service interruptions and infrastructure failure. This study proposes a differential equation–based framework for analyzing the dynamic behavior of rural water distribution systems, with application to Wilson County, Texas.

The research conceptualizes rural water infrastructure as an interconnected system characterized by time-dependent changes in storage, pressure, demand variability, capital investment, and environmental stressors. By modeling these interacting components within a systems framework, the study examines how disturbances—such as demand spikes, drought conditions, or deferred maintenance—propagate through the system and influence long-term reliability.

Beyond hydraulic mechanics, this work integrates operational and structural dynamics to explore resilience under constrained financial and managerial conditions typical of rural utilities. The goal is to provide a quantitative foundation for understanding stability, risk accumulation, and intervention strategies in small-scale water systems.

Chi-Chao Tsai cct375@tamu.edu

Texas A&M University

Wave Equation in 2D with Non-linear Boundary Condition and Chaos

We explore the possibility of chaotic solution to 2D wave equations by making part of the boundary conditions non-linear.

Mary Vaughan vaughan@txstate.edu

Texas State University

Continuous Symmetrizations and Uniqueness of Solutions to Nonlocal Equations

In this talk, we will begin by discussing fractional thin film equations which can be seen as the gradient flow of nonlocal energy functionals. We establish the uniqueness of nonnegative stationary solutions and present their explicit form. Towards this end, we show that nonlocal energies are strictly decreasing under the continuous Steiner rearrangement. This work is joint with Matías Delgadino (UT Austin)

John Villavert john.villavert@utrgv.edu

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Hardy-Sobolev Type Inequalities and Supercritical Problems

In this talk, we examine supercritical variants of a Hardy—Sobolev-type embedding and related elliptic problems that incorporate power nonlinearities with strongly variable exponents. In particular, we describe a variational approach used to derive supercritical Hardy-Sobolev-type inequalities and obtain existence results for the Dirichlet problem to a class of elliptic problems in the unit ball. We will also discuss complimentary non-existence results in both ball domains and the whole space are also discussed.

James D. Walker james.walker@swri.org

Southwest Research Institute

An Example of Unusual Size Scaling in Failure Mechanics

When a high speed or hypervelocity impact occurs, a crater is formed. Size scaling of this event is of interest, meaning, for example, how the resulting crater properties change as the initial impactor size increases. While the crater depth normalized by impactor diameter is fairly insensitive to initial impactor size, there are other aspects of the cratering process where dimensionless results do depend on the initial size of the impactor. These include (all appropriately normalized) crater diameter, mass of material liberated as ejecta, and momentum of the ejecta material. A shear-band motived nonlocal material failure model was developed and is presented that has a size dependence due to a fixed slip length to material failure. Assuming rapid deformation allows the failure model to be recast to a failure model that includes a strain rate to the 2/3rds power term in the failure strain criterion. When incorporated into the large continuum mechanics Eulerian solver CTH (which solves the hyperbolic partial differential equation system of mass, momentum, and energy conservation, using artificial viscosity to handle shocks (sometimes referred to as shock capturing)), this model reproduces the ejecta mass size scaling behavior seen in experiments with an aluminum alloy (Al 2024-T351). Experimental and computational results and comparisons are presented. In the experiments, performed at NASA Ames and SwRI, the initial spherical impactor diameter ranged from 0.16 cm to 3.0 cm (a size scale factor of 19) and the impact speed ranged from 0.5 to 8.5 km/s. However, in the modeling, ejecta momentum (referred to as momentum enhancement) scales with ejecta mass which is not what is seen in the experiments, so there is still work to do in modeling the cratering. Momentum enhancement and its scaling in rock is directly applicable to planetary defense: comments will be made with regard to these results and the 2022 Double Asteroid Redirection Test (DART) spacecraft impact into the asteroid Dimorphos at 6.14 km/s. [See "Size Scaling of Hypervelocity-impact Ejecta Mass and Momentum Enhancement: Experiments and a Nonlocal-shear-band-motivated Strain-rate-dependent Failure Model," J. D. Walker, S. Chocron, D. J. Grosch, Int. J. Impact Engng 135 (2020) 103388:1-14 DOI: 10.1016/j.ijimpeng.2019.103388; "Modern Impact and Penetration Mechanics," Walker, Cambridge University Press, 2021.]

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Frequency Function Method to Quantitative Unique Continuation for Elliptic Equations with Hölder Lower Order Terms

We study quantitative unique continuation for elliptic equations with lower order terms of H"older regularity via a frequency function method. We establish quantitative three-ball inequalities and corresponding vanishing-order bounds. Our results are quantitative with explicit dependence of the three-ball constants and the vanishing-order exponents on the H"older exponent, which has a unified framework matching sharp endpoint results. We also adapt a lifting procedure for gradient terms, by which we can infer the H"older case from the Lipschitz case with the idea of mollification. This is a joint work with Long Teng, Jiuyi Zhu.

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Texas A&M University

PDE-Constrained Motion Imitation via Modal Analysis and Physics-Informed Neural Networks

In this talk, I present a PDE-constrained framework for dinosaur motion imitation that integrates modal analysis, LSTM networks, and physics-informed neural networks (PINNs). Each dinosaur is modeled as a deformable elastic body governed by a second-order hyperbolic system from continuum mechanics. After finite element discretization, the high-dimensional dynamics are projected onto a reduced modal subspace using spectral decomposition, yielding a compact dynamical system for modal coefficients. The central challenge is to generate physically consistent motion for a target dinosaur with different geometry and spectral structure given motion data from a source model. We address this by combining LSTM networks to learn temporal evolution with PINNs that enforce the governing structural dynamics through residual minimization in the loss function. This approach embeds PDE constraints directly into the learning process, ensuring stability and physical admissibility, and illustrates how spectral theory and reduced-order modeling can be integrated with modern neural architectures for cross-anatomical motion transfer.

Karen Yagdjian karen.yagdjian@utrgv.edu
UTRGV

Spherical Waves in the Expanding Universe

In this talk, we present an explicit formula for the wave functions of the spherically symmetric scalar and Dirac fields emitted to the Friedmann-Lemaitre-Robertson-Walker universe with the scale factor generated by the de Sitter model. The derivation of the explicit formula is based on the application of some integral transform, which is an analytical mechanism that generates a solution of the massive or massless scalar field in the curved spacetime from the massless scalar field in the Minkowski space. We also prove an exponential decay in time of the tail of the solution in the Minkowski space and test the decay in time of the field in the de Sitter space. As an application of these explicitly written solutions of the Klein-Gordon equation, we test the decay in time of the field generated by a pionic atom.