Plenary Speakers Spotlight

**Alina Chertock** is a Professor of Mathematics, the Head of the Mathematics Department and the Associate Director of the Center for Research in Scientific Computation at North Carolina State University (NCSU). Her research expertise includes: Applied Nonlinear Partial Differential Equations, Scientific Computing, Numerical Analysis, Multiscale Models, Uncertain Phenomena, and Experimental Asymptotics. Dr. Chertock earned her Master's degree in Applied Mathematics from the Lomonosove Moscow State University in 1989 and her Ph. D. in Applied Mathematics from Tel-Aviv University in 1999. She held visiting positions at Institute of Mathematics, University of Mainz, Institut de Mathematiques de Toulouse, Universite Paul Sabatier, Jiao Tong University, Brown University, Moscow Institute of Physics and Technology, and UC Berkeley. She has received numerous research grants and awards from the NSF, ONR and Simons. Dr. Chertock has mentored several postdoctoral fellows and Ph. D. students. She has organized over 30 conferences and workshops, given 150 invited talks and has published over 60 research papers. She is serving as Associate Editor of the journals: Kinetic and Related Models, SIAM journal on Applied Mathematics, Journal of Scientific Computing and Communications in Computational Physics.

**Jerome Goldstein** is a Professor of Mathematics at the University of Memphis. He earned his Bachelor’s (’63), Master’s (’64) and Ph.D (’67) degrees from Carnegie Mellon University. He has also held appointments as Professor at Tulane University and Louisiana State University. He has held visiting positions at the IAS in Princeton, the University of London, and MSRI in UC Berkeley and also at Brasilia, Federal University of Rio de Janeiro, Besancon, Poitiers, Bari, Bologna, Graz, Strathclyde, Tuebingen, Carnegie Mellon and Stanford. He has close to 300 publications and supervised 30 PhD students. Originally a Probabilist, his research interests include Mathematical Physics, Chemistry, specially Quantum Theory, Mathematical Finance, Linear and Nonlinear PDEs, Semigroups, and Mathematical Analysis in general. In 2013, he became a fellow of the American Mathematical Society for his contributions to PDEs and its applications, and for the dissemination of mathematics to a wider audience.

**Maia Martcheva** is a Professor of Mathematics at University of Florida. She is also an affiliated Professor in their Department of Biology. Her research expertise includes: Mathematical Biology, Population Dynamics, Mathematical Epidemiology, Mathematical Demography, Mathematical Ecology, Nonlinear PDEs, and Numerical Analysis. Dr. Martcheva earned a Master’s degree in Mathematics from the University of Sofia, Bulgaria in 1988. She completed her Ph.D. in Applied Mathematics in 1998 at Purdue University. She was a postdoctoral fellow at the University of Minnesota and became an Assistant Professor at University of Florida in 2003. She was awarded many NSF grants, including the NSF ADVANCE fellow position. She held a Vice Chair position at SIAG Life Sciences from 2012 to 2014. Dr. Martcheva has organized 8 conferences and scientific forums. She has given over 80 invited talks. She is an editor of the Mathematical Biosciences, Biological Dynamics and Biological Systems journals. She has supervised 10 PhD, 8 MSc and Undergraduate theses, and has published more than 100 papers. She is the author of the books, “An Introduction to Mathematical Epidemiology” and “Gender-Structured Population Modeling: Mathematical Methods, Numerics, and Simulations”. 
Welcome Message from the Conference Chair:

It is a great pleasure for us to welcome you to the 39th Southeastern-Atlantic Regional Conference on Differential Equations (SEARCDE) at Embry-Riddle Aeronautical University, Daytona Beach, Florida.

Over the past 38 years, SEARCDE has grown to be one of the major conferences in the southeastern region of the United States. Starting from the first conference at Virginia Tech in 1981, the conference has been rotating among various host institutions in the southeastern area. The conference represents diversity in theory, applications, modeling, and scientific computations of differential equations, including: PDEs arising from physical sciences, geophysical sciences, biological sciences, medical sciences, engineering, business, economics, and social sciences. The 39th SEARCDE continues this tradition maintaining high-quality research in diverse disciplines.

We are honored to have Professor Alina Chertock from North Carolina State University, Professor Jerome Goldstein from The University of Memphis, and Professor Maia Martcheva from University of Florida as plenary speakers. In addition, we are excited to have two distinguished professors from Florida as invited speakers, S. Roy Choudhury from University of Central Florida and Robert S. Cantrell from University of Miami. There are 82 contributed presentations scheduled in 24 parallel sessions and their research areas include linear and nonlinear analysis of differential equations, mathematical fluid mechanics, mathematical biology, and numerical and computational PDEs. The aim of the conference is to bring participants at various stages of their career in order to provide a unique platform for dissemination and exchange of their novel scientific findings.

We hope the 39th SEARCDE will open collaborations among researchers in diverse disciplines through interactions during coffee breaks, lunch, and a banquet dinner.

We would like to thank the National Science Foundation and Embry-Riddle Aeronautical University for their generous support.

We thank you for attending and supporting the 39th SEARCDE. Best wishes for a productive and enjoyable conference.

On behalf of the organizing committee,
Keshav Acharya, Chair, the 39th SEARCDE
39th Southeastern-Atlantic Regional Conference on
Differential Equations (SEARCDE 2019)

Embry-Riddle Aeronautical University
1 Aerospace Blvd., Daytona Beach, FL. 32114

October 26 - 27, 2019

Program and Abstracts
## Summary of the 39th SEARCDE 2019 Program

### Saturday October 26th

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
<th>Location</th>
</tr>
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<tbody>
<tr>
<td>11:00 am – 6:00 pm</td>
<td>Registration (Mori Hosseini Student Union Event Center – 165 A/B/C)</td>
<td></td>
</tr>
<tr>
<td>12:00 pm – 12:10 pm</td>
<td>Welcome Address</td>
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<tr>
<td></td>
<td><strong>Karen Gaines</strong>, Dean of College of Arts and Sciences, Embry-Riddle Aeronautical University-Daytona Beach</td>
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<tr>
<td>12:15 pm – 1:15 pm</td>
<td>Plenary Talk I</td>
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<td></td>
<td><strong>Jerome Goldstein</strong>: Instantaneous Blowup, Old and New Results</td>
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<td>Moderator: Keshav Acharya</td>
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<tr>
<td>1:25 pm – 1:55 pm</td>
<td>Invited Talk I</td>
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<td></td>
<td><strong>S. Roy Choudhury</strong>: Distributed Delay Effects on Coupled van der Pol Oscillators, and a Chaotic van der Pol-Rayleigh System with Parametric Forcing</td>
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<td></td>
<td>Moderator: Stefan C. Mancas</td>
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<tr>
<td>119x674 Parallel Sessions (College of Arts and Science, Building 419)</td>
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<tr>
<td>2:20 pm – 2:40 pm</td>
<td>Session 1</td>
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<td>COAS 125</td>
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<td>R. Adams</td>
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<td>2:40 pm – 3:00 pm</td>
<td>Session 2</td>
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<td>COAS 126</td>
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<td></td>
<td>S. Mancas</td>
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<tr>
<td>3:00 pm – 3:20 pm</td>
<td>Session 3</td>
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<td>COAS 128.1</td>
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<td></td>
<td>H. Khanal</td>
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<tr>
<td>3:20 pm – 3:40 pm</td>
<td>Session 4</td>
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<td>COAS 205</td>
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<td>A. Aryal</td>
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<td>3:40 pm – 4:00 pm</td>
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<td></td>
<td>G. Spradlin</td>
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<tr>
<td>4:00 pm – 4:20 pm</td>
<td>Session 6</td>
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<td>D. Adhikari</td>
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<tr>
<td>4:40 pm – 4:40 pm</td>
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<td>F. Drullion</td>
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<tr>
<td>5:15 pm – 6:15 pm</td>
<td>Plenary Talk II</td>
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<tr>
<td></td>
<td>Alina Chertock: Convergence of a Particle Method and Global Weak Solutions for a Family of Evolutionary PDEs</td>
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<td></td>
<td>Moderator: Lorena Bociu</td>
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<tr>
<td>6:30 pm – 6:35 pm</td>
<td>Reception Remarks.</td>
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<td></td>
<td><strong>Jayathi Raghavan</strong>, Chair of Mathematics Department, Embry-Riddle Aeronautical University</td>
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<tr>
<td>6:30 pm – 8:30 pm</td>
<td>Banquet (Henderson Welcome Center, Building 602)</td>
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### Sunday October 27th

<table>
<thead>
<tr>
<th>Time</th>
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<tbody>
<tr>
<td>7:30 am – 8:30 am</td>
<td>Breakfast</td>
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<tr>
<td>8:00 am – 12:00 pm</td>
<td>Registration</td>
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<tr>
<td>8:30 am – 9:30 am</td>
<td><strong>Maia Martcheva</strong>: Modeling Zika</td>
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<td>Moderator: Sirani M. Perera</td>
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<tr>
<td>9:40 am – 10:40 am</td>
<td>Plenary Talk III</td>
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<tr>
<td></td>
<td><strong>Robert Stephen Cantrell</strong>: Evolutionary Stability of Ideal Free Dispersal under Spatial Heterogeneity and Time Periodicity</td>
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<td>Moderator: Keshav Acharya</td>
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<tr>
<td>11:00 am – 11:20 am</td>
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<td>F. Drullion</td>
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<td>R. Adams</td>
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<td>11:40 am – 12:00 pm</td>
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<td>R. Dahal</td>
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<td>12:00 pm – 12:45 pm</td>
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<td>G. Rosu</td>
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<td>B. Khatri</td>
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<td>A. Stokolos</td>
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<td>P. Chhetri</td>
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[Full Schedule and Details Provided in the Content]
<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
<th>Location</th>
<th>Speaker</th>
<th>Title</th>
<th>Abstract</th>
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<tbody>
<tr>
<td>Saturday, October 26</td>
<td>Registration</td>
<td>Mori Hosseini Student Union Event Center – 165 A/B/C</td>
<td>-</td>
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</tr>
<tr>
<td>11:00am – 6:00pm</td>
<td>Welcome Address</td>
<td>Mori Hosseini Student Union Event Center – 165 A/B/C</td>
<td>Keshav Acharya</td>
<td>Welcome - Karen Gaines, Dean of College of Arts and Sciences, Embry-Riddle Aeronautical University-Daytona Beach</td>
<td>-</td>
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<tr>
<td>12:00pm – 12:10pm</td>
<td>Plenary Talk I</td>
<td>Mori Hosseini Student Union Event Center – 165 A/B/C</td>
<td>Jerome Goldstein</td>
<td>Instantaneous Blowup, Old and New Results</td>
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<tr>
<td>12:15pm – 1:15pm</td>
<td>Invited Talk I</td>
<td>Mori Hosseini Student Union Event Center – 165 A/B/C</td>
<td>S. Roy Choudhury</td>
<td>Distributed Delay Effects on Coupled van der Pol Oscillators, and a Chaotic van der Pol-Rayleigh System with Parametric Forcing</td>
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<tr>
<td>1:25pm – 1:55pm</td>
<td>Parallel Sessions 1-6</td>
<td>Room COAS 125</td>
<td>Harish Bhatt</td>
<td>An Efficient and Accurate High-Order Method in Application to Space-Fractional Reaction-Diffusion Systems with Nonhomogeneous Boundary Conditions</td>
<td>-</td>
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<tr>
<td>2:20pm – 2:40pm</td>
<td>Module 1</td>
<td>Room COAS 125</td>
<td>Chi Phan</td>
<td>Random Attractor for Stochastic Hindmarsh-Rose Equations with Multiplicative Noise</td>
<td>-</td>
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<tr>
<td>2:40pm – 3:00pm</td>
<td>Module 2</td>
<td>Room COAS 125</td>
<td>Ronald Adams</td>
<td>Dissipative Periodic and Chaotic Patterns to the KDV-Burgers and Gardner Equations</td>
<td>-</td>
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<tr>
<td>3:00pm – 3:20pm</td>
<td>Module 3</td>
<td>Room COAS 125</td>
<td>Min Wang</td>
<td>Existence of Solutions for a Second Order Discrete Boundary Value Problem with Mixed Periodic Boundary Conditions</td>
<td>-</td>
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<tr>
<td>3:20pm – 3:40pm</td>
<td>Module 4</td>
<td>Room COAS 125</td>
<td>Emma Previato</td>
<td>Special-Functions Solutions of Burgers’ Equation</td>
<td>-</td>
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<tr>
<td>2:20pm – 2:40pm</td>
<td>Module 5</td>
<td>Room COAS 125</td>
<td>Nora Entekhabi</td>
<td>Inverse Source Problems for Wave Propagation</td>
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<tr>
<td>2:40pm – 3:00pm</td>
<td>Module 6</td>
<td>Room COAS 125</td>
<td>Nathan Hayford</td>
<td>Painlevé VI, Isomonodromy, and Fredholm Determinants</td>
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<tr>
<td>3:00pm – 3:20pm</td>
<td>Module 7</td>
<td>Room COAS 125</td>
<td>Stefan C. Manicas</td>
<td>The Collapse of a Spherical Bubble in a Water Tank in Connection with Einstein’s Field Equations</td>
<td>-</td>
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<tr>
<td>3:20pm – 3:40pm</td>
<td>Module 8</td>
<td>Room COAS 125</td>
<td>Zachary Denton</td>
<td>Quasilinearization Method for RL Fractional Systems</td>
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<tr>
<td>2:20pm – 2:40pm</td>
<td>Module 9</td>
<td>Room COAS 125</td>
<td>Friday I. Oyakhire</td>
<td>Tenth Order Compact Finite Difference Schemes for One Dimensional Helmholtz Equations using Neumann Boundary Condition</td>
<td>-</td>
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<tr>
<td>2:40pm – 3:00pm</td>
<td>Module 10</td>
<td>Room COAS 125</td>
<td>Kabita Luitel</td>
<td>The Study of Numerical Method for Transient Heat Transfer in Cylindrical Living Tissue</td>
<td>-</td>
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<tr>
<td>3:00pm – 3:20pm</td>
<td>Module 11</td>
<td>Room COAS 125</td>
<td>Harihar Khanal</td>
<td>Numerical Methods for Variable Order Differential Equations</td>
<td>-</td>
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<tr>
<td>3:20pm – 3:40pm</td>
<td>Module 12</td>
<td>Room COAS 125</td>
<td>Madhav Wagley</td>
<td>Non-Uniform Mesh High-Order Discretization for the Generalized Burgers Equations</td>
<td>-</td>
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<tr>
<td>2:20pm – 2:40pm</td>
<td>Module 13</td>
<td>Room COAS 125</td>
<td>Matthew McCurdy</td>
<td>Convection in Coupled Fluid-Porous Media Systems</td>
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<tr>
<td>2:40pm – 3:00pm</td>
<td>Module 14</td>
<td>Room COAS 125</td>
<td>Aaron Rapp</td>
<td>Optimization of the Penalty Parameter for the Dual-Wind Discontinuous Galerkin Methods on a Prototypical Second Order PDE</td>
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<td>3:00pm – 3:20pm</td>
<td>Module 15</td>
<td>Room COAS 125</td>
<td>Ashok Aryal</td>
<td>Classical Bernoulli Type Free Boundary Problems</td>
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<tr>
<td>3:20pm – 3:40pm</td>
<td>Module 16</td>
<td>Room COAS 205</td>
<td>Amin Boumenir</td>
<td>Eigenfunctions of Quadratic Pencil Operators</td>
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<td>Time</td>
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<tr>
<td>2:40pm – 3:00pm</td>
<td>Yunxiang Bai</td>
<td>Generalized Monotone Method for Nonlinear Caputo Fractional Impulsive Differential Equations</td>
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<tr>
<td>3:00pm – 3:20pm</td>
<td>Sze-Man Ngai</td>
<td>Spectral Asymptotics of Laplacians Defined by Fractal Measures and Some Applications</td>
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<tr>
<td>3:20pm – 3:40pm</td>
<td>Lingju Kong</td>
<td>On the Principle Eigenvalue of a Biharmonic System</td>
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**Session 6 (Room COAS 207)**

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<th>Time</th>
<th>Speaker</th>
<th>Title</th>
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<tbody>
<tr>
<td>2:20pm – 2:40pm</td>
<td>Timothy I. Myers</td>
<td>A Constructive Solution to the Ornstein-Uhlenbeck Equations on a Separable Banach Space of Infinite Dimension</td>
</tr>
<tr>
<td>2:40pm – 3:00pm</td>
<td>Hassan Almusawa</td>
<td>Symmetries of the Canonical Geodesic Equations of Five-Dimensional Nilpotent Lie Algebras</td>
</tr>
<tr>
<td>3:00pm – 3:20pm</td>
<td>Satbir Malhi</td>
<td>A Note on the Resolvent Estimates of the Damped Wave Equation via Observability Estimate</td>
</tr>
<tr>
<td>3:20pm – 3:40pm</td>
<td>Dhruba Adhikari</td>
<td>On the Uniqueness of Topological Degrees for Densely Defined Operators of Type (S-)</td>
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<tr>
<td>3:40pm – 4:00pm</td>
<td></td>
<td>Coffee Break (Mori Hosseini Student Union Event Center – 165 A/B/C)</td>
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**Coffee Break (Mori Hosseini Student Union Event Center – 165 A/B/C)**

**Parallel Sessions 1-6**

**Session 1 (Room COAS 125)**

<table>
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<tr>
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<tr>
<td>4:00pm – 4:20pm</td>
<td>Nicki Boardman</td>
<td>The Ideal 2D MHD Equations</td>
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<tr>
<td>4:20pm – 4:40pm</td>
<td>Lorena Bociu</td>
<td>Fluid-Structure Interactions: Control and Optimization</td>
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<tr>
<td>4:40pm – 5:00pm</td>
<td>Shahrdad G. Sajjadi</td>
<td>The Time Periodic Solution of the Burgers Equation on the Half-Line and an Application to Steady Streaming</td>
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**Session 2 (Room COAS 126)**

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<th>Title</th>
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<tr>
<td>4:00pm – 4:20pm</td>
<td>Sunil Giri</td>
<td>Backward Bifurcation in Vector-Borne Model with Direct Transmission</td>
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<tr>
<td>4:20pm – 4:40pm</td>
<td>Vin M. Isaia</td>
<td>Polynomial Simulation of Functional Differential Equations with Delayed Argument</td>
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<tr>
<td>4:40pm – 5:00pm</td>
<td>Hasala S. K. G. Kantakannalage</td>
<td>Characterizations of String Stability for Systems with Delays</td>
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**Session 3 (Room COAS 128.1)**

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<tbody>
<tr>
<td>4:00pm – 4:20pm</td>
<td>Netra Khanal</td>
<td>A New Predictive Analytical Model for Software Vulnerability Recovery Process</td>
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<tr>
<td>4:20pm – 4:40pm</td>
<td>Vijay Kunwar</td>
<td>Branching Patterns, Dessins and Rational Functions</td>
</tr>
<tr>
<td>4:40pm – 5:00pm</td>
<td>David Williams</td>
<td>Introducing Challenging Modeling Problems Early with Chebfun Add-Ons for MATLAB</td>
</tr>
</tbody>
</table>

**Session 4 (Room COAS 205)**

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Title</th>
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</thead>
<tbody>
<tr>
<td>4:00pm – 4:20pm</td>
<td>Gulsah Yeni</td>
<td>SIS and SIR Epidemic Models on Time Scales</td>
</tr>
<tr>
<td>4:20pm – 4:40pm</td>
<td>Buddhi Pantha</td>
<td>Mathematical Model for Rabies Transmission and Control in Nepal</td>
</tr>
<tr>
<td>4:40pm – 5:00pm</td>
<td>Sirani M. Perera</td>
<td>Fast Split-Radix and Radix-4 Discrete Cosine Transform Algorithms</td>
</tr>
</tbody>
</table>

**Session 5 (Room COAS 206)**

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>4:00pm – 4:20pm</td>
<td>Gisèle Goldstein</td>
<td>Recent Advancements in Mathematical Finance</td>
</tr>
<tr>
<td>4:20pm – 4:40pm</td>
<td>Karthikkeya Manilakapalle</td>
<td>Implicit Finite Difference Method for Pricing of Derivatives</td>
</tr>
<tr>
<td>4:40pm – 5:00pm</td>
<td>Timothy Smith</td>
<td>A Statistical Learning Model Utilized to Validate a Market Hypothesis</td>
</tr>
</tbody>
</table>

**Session 6 (Room COAS 207)**

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>4:00pm – 4:20pm</td>
<td>Vani Cheruvu</td>
<td>Wavelet Regularization for Ill-Posed Problems</td>
</tr>
<tr>
<td>4:20pm – 4:40pm</td>
<td>Benjamin Friedman</td>
<td>Existence of Solutions to Boundary Value Problems on Infinite Intervals</td>
</tr>
<tr>
<td>4:40pm – 5:00pm</td>
<td>Maya Chhetri</td>
<td>Some Bifurcation Results for Fractional Laplacian Problems</td>
</tr>
</tbody>
</table>

Plenary Talk II (Mori Hosseini Student Union Event Center – 165 A/B/C)

Convergence of a Particle Method and Global Weak Solutions for a Family of Evolutionary PDEs

**Reception Remarks** - Jayathi Raghavan, Chair of Mathematics Department, Embry- Riddle Aeronautical University

**Reception Dinner (Henderson Welcome Center 602)**
<table>
<thead>
<tr>
<th>Time</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>7:30am - 8:30am</td>
<td>Breakfast (Mori Hosseini Student Union Event Center – 165 A/B/C)</td>
</tr>
<tr>
<td>8:00am - 12:00pm</td>
<td>Registration</td>
</tr>
<tr>
<td>8:30am - 9:30am</td>
<td>Plenary Talk III (Mori Hosseini Student Union Event Center – 165 A/B/C) Modeling Zika</td>
</tr>
<tr>
<td>9:40am - 10:40am</td>
<td>Invited Talk II (Mori Hosseini Student Union Event Center – 165 A/B/C) Evolutionary Stability of Ideal Free Dispersal under Spatial Heterogeneity and Time Periodicity</td>
</tr>
</tbody>
</table>

**Session 1 (Room COAS 125)**

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>11:00am - 11:20am</td>
<td>Rasika L. Mahawattege</td>
<td>Fluid-Viscoelastic Structure Interaction</td>
</tr>
<tr>
<td>11:20am - 11:40am</td>
<td>Julia Ream</td>
<td>Investigating the Impact of Supercritical Fluid Properties on the Turbulence Physics of the Round Turbulent Jet</td>
</tr>
<tr>
<td>11:40am - 12:00pm</td>
<td>Frederique Drullion</td>
<td>Sensitivity of a Coupled Wind /Wave Model Using Energy Transfer Schemes for Growing Waves</td>
</tr>
</tbody>
</table>

**Session 2 (Room COAS 126)**

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>11:00am - 11:20am</td>
<td>Nalin Fonseka</td>
<td>Singular Reaction Diffusion Equations where a Parameter Influences the Reaction Term and the Boundary Condition (I)</td>
</tr>
<tr>
<td>11:20am - 11:40am</td>
<td>Amila Muthunayake</td>
<td>Singular Reaction Diffusion Equations where a Parameter Influences the Reaction Term and the Boundary Condition (II)</td>
</tr>
<tr>
<td>11:40am - 12:00pm</td>
<td>Ratnasingham Shivaji</td>
<td>Uniqueness of Positive Radial Solutions for a Class of Infinite Semipositone p-Laplacian Problems in a Ball</td>
</tr>
</tbody>
</table>

**Session 3 (Room COAS 128.1)**

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>11:00am - 11:20am</td>
<td>Elliot Hollifield</td>
<td>Solutions for a Class of Fractional Laplacian Problems</td>
</tr>
<tr>
<td>11:20am - 11:40am</td>
<td>Qingtian Zhang</td>
<td>Solutions of GSQG Front Problems</td>
</tr>
<tr>
<td>11:40am - 12:00pm</td>
<td>Rajendra Dahal</td>
<td>A Uniformly Sharp Convexity Result for Discrete Fractional Sequential Differences</td>
</tr>
</tbody>
</table>

**Session 4 (Room COAS 205)**

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>11:00am - 11:20am</td>
<td>Krishna P. Pokharel</td>
<td>An Isospectral Flow on Banded Matrices and its Optimality</td>
</tr>
<tr>
<td>11:20am - 11:40am</td>
<td>Divine Wanduku</td>
<td>The Stochastic Permanence of Disease and the Stationary Behavior for a Class of Nonlinear SEIRS Epidemic Models</td>
</tr>
<tr>
<td>11:40am - 12:00pm</td>
<td>Peng Feng</td>
<td>Role of Regulatory T Cells on a Tumor-Immune System with Immunotherapy</td>
</tr>
</tbody>
</table>

**Session 5 (Room COAS 206)**

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>11:00am - 11:20am</td>
<td>Laurentiu Sega</td>
<td>Reduced Fertility and Asymptotics of the Logistic Model</td>
</tr>
<tr>
<td>11:20am - 11:40am</td>
<td>Xinyue (Evelyn) Zhao</td>
<td>The Impact of Time Delay in a Tumor Model</td>
</tr>
<tr>
<td>11:40am - 12:00pm</td>
<td>Ahtam H. Alzahrani</td>
<td>Traveling Waves in Discrete Models of Biological Populations with Sessile Stages</td>
</tr>
</tbody>
</table>

**Session 6 (Room COAS 207)**

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>11:00am - 11:20am</td>
<td>Alexander M. Stokolos</td>
<td>Search for Cycles of Long Length in Discrete Dynamical Systems</td>
</tr>
<tr>
<td>11:20am - 11:40am</td>
<td>Jaffar Ali Shahul-Hameed</td>
<td>Positive Solutions for a Derivative Dependent p-Laplacian Equation with Riemann-Stieltjes Integral Boundary Conditions</td>
</tr>
<tr>
<td>11:40am - 12:00pm</td>
<td>Pradeep G. Chhetri</td>
<td>Existence of the Solution in the Large for Caputo Fractional Reaction Diffusion Equation by Picard’s Method</td>
</tr>
</tbody>
</table>

**Parallel Sessions 1-6**

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>12:50pm - 1:10pm</td>
<td>Jiehua Zhu</td>
<td>Two Regularization Models for Computed Tomography Image Reconstruction from Limited Projection Data</td>
</tr>
<tr>
<td>1:10pm - 1:30pm</td>
<td>Rossana Capuani</td>
<td>Mean Field Games with State Constraints</td>
</tr>
<tr>
<td>1:30pm - 1:50pm</td>
<td>Rakesh Kumar</td>
<td>Effects of Time-Varying Impulses on Exponential Stability of Inertial BAM Neural Network with Mixed Time-Varying Delays</td>
</tr>
</tbody>
</table>

**Session 2 (Room COAS 126)**

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>12:50pm - 1:10pm</td>
<td>Marcelo E. Rubio</td>
<td>Well-Posedness Results on Non-Linear Classical Field Theories in Physics</td>
</tr>
<tr>
<td>1:10pm - 1:30pm</td>
<td>Evans M. Harrell II</td>
<td>How Small Can the Gap Be between Eigenvalues of the Schrödinger Equation?</td>
</tr>
<tr>
<td>1:30pm - 1:50pm</td>
<td>Suthirut Chareumphon</td>
<td>Vanishing Relaxation Time Dynamics of the Jordan Moore-Gibson-Thompson (JMG) Equation Arising in High Frequency Ultrasound</td>
</tr>
<tr>
<td>1:50pm - 2:10pm</td>
<td>Haret C. Rosu</td>
<td>Factorization of Fractional Quantum Oscillators</td>
</tr>
</tbody>
</table>

**Session 3 (Room COAS 128.1)**

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Title</th>
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<tbody>
<tr>
<td>12:50pm - 1:10pm</td>
<td>Tien K. Nguyen</td>
<td>Metric Entropy for Hyperbolic Conservation Laws</td>
</tr>
<tr>
<td>1:10pm - 1:30pm</td>
<td>Sivaguru S. Ravindran</td>
<td>Penalization of Dirichlet Optimal Control Problem for Magnetohydrodynamics</td>
</tr>
<tr>
<td>1:30pm - 1:50pm</td>
<td>Salehdeh Seif</td>
<td>Convergence of the Method of Finite Differences in Optimal Control for Second Order Elliptic PDEs</td>
</tr>
<tr>
<td>Time</td>
<td>Speaker</td>
<td>Title</td>
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<tr>
<td>1:50pm – 2:10pm</td>
<td>Howard M. Allison</td>
<td>Sufficient Conditions for Stability and Asymptotic Convergence of a PEEC Model Stable Linear Autonomous Neutral Functional Differential Equation with Nonlinear Perturbations</td>
</tr>
<tr>
<td>12:50pm – 1:10pm</td>
<td>Ramjee P. Sharma</td>
<td>Numerical Solutions of 2D Boussinesq Equations with Fractional Dissipation</td>
</tr>
<tr>
<td>1:10pm – 1:30pm</td>
<td>Nilan Udayanga</td>
<td>Hardware Accelerated Fast FDTD of Time Dependent Maxwell’s Equations on Xilinx RF SoC</td>
</tr>
<tr>
<td>1:30pm – 1:50pm</td>
<td>Ali Hagverdiyev</td>
<td>Optimal Control of Coefficients in Parabolic Free Boundary Problems Modeling Laser Ablation</td>
</tr>
<tr>
<td>1:50pm – 2:10pm</td>
<td>Balarm Khatri Ghimire</td>
<td>Hybrid Chebyshev Polynomial Scheme for Solving Elliptic Partial Differential Equations</td>
</tr>
</tbody>
</table>

**Session 5 (Room COAS 206)**

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
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</tr>
</thead>
<tbody>
<tr>
<td>12:50pm – 1:10pm</td>
<td>Nsoki Mavinga</td>
<td>Existence Results for Nonlinear Perturbations of Asymmetric Spectrum with Weights</td>
</tr>
<tr>
<td>1:10pm – 1:30pm</td>
<td>Subhash Subedi</td>
<td>Quenching Problem for Two Dimensional Time Fractional Reaction-Diffusion Equation via Lower Solution Method</td>
</tr>
<tr>
<td>1:30pm – 1:50pm</td>
<td>Manki Cho</td>
<td>Steklov Approximations of Solutions of Laplacian Boundary Value Problems</td>
</tr>
<tr>
<td>1:50pm – 2:10pm</td>
<td>Nimisha Pathak</td>
<td>Lyapunov-Type Inequality and Eigen Value Estimate for a Fractional Problem with Hilfer Derivative</td>
</tr>
</tbody>
</table>

**Session 6 (Room COAS 207)**

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<tr>
<th>Time</th>
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</thead>
<tbody>
<tr>
<td>12:50pm – 1:10pm</td>
<td>Diego Ramirez</td>
<td>Generalized Monotone Iterative Techniques for Caputo Fractional IVP with an Application to Biological Models</td>
</tr>
<tr>
<td>1:10pm – 1:30pm</td>
<td>Steven J. Gilmore</td>
<td>A Model of Debt with Bankruptcy Risk and Currency Devaluation</td>
</tr>
<tr>
<td>1:30pm – 1:50pm</td>
<td>Muath Awadalla</td>
<td>Modeling the Dependence of Atmospheric Pressure with Altitude using Caputo and Caputo-Fabrizio Fractional Derivatives</td>
</tr>
</tbody>
</table>
1. Optimal Control of Coefficients in Parabolic Free Boundary Problems Modeling Laser Ablation

Ugur Abdulla  
Florida Institute of Technology  
abdulla@fit.edu

Jonathan Goldfarb  
Florida Institute of Technology  
jgoldfar@fit.edu

Ali Hagverdiyev*  
Florida Institute of Technology  
ahaqverdiyev2011@my.fit.edu

Abstract  
Optimal control of coefficients in the free boundary problem for the second order parabolic PDE modeling biomedical engineering problem on the laser ablation of biological tissues is analyzed. Optimal control in Hilbert-Besov spaces framework is employed where coefficient of the PDE and free boundary are components of the control vector and optimality criteria are based on the final moment measurement of the temperature and position of the free boundary. Discretization by finite differences is pursued, and convergence of the discrete optimal control problems to the original problem is proved. Gradient descent algorithm based on Frechet differentiability in Hilbert-Besov spaces complemented with preconditioning or increase of regularity of the Frechet gradient through implementation of the Riesz representation theorem is implemented. Numerical results are demonstrated for the optimal control of the two-phase Stefan problem based on the optimize-then-discretize approach through implementation of the gradient method in Hilbert-Besov spaces, preconditioning, simultaneous and individual identification of control parameters, as well as sensitivity analysis with respect to initial data.

2. On the Uniqueness of Topological Degrees for Densely Defined Operators of Type $(S_+)$

Dhruba Adhikari  
Kennesaw State University  
dadhikar@kennesaw.edu

Abstract  
Let $X$ be a separable reflexive Banach Space, $G$ be a bounded open subset of $X$, and $L$ a dense linear subspace of $X$. The uniqueness of the topological degree $d(A, G, 0)$, for mappings $A : X \supset D(A) \to X^*$ satisfying condition $(S_+)_{L}$ invariant under certain homotopy is established. The existence of
such a topological degree is first established by Kartsotos and Skrypnik, and later, by Berkovits by using different approach.

3. Symmetries of the Canonical Geodesic Equations of Five-Dimensional Nilpotent Lie Algebras

Hassan Almusawa*
Virginia Commonwealth University, Qatar
almusawah@vcu.edu

Ryad Ghanam
Virginia Commonwealth University, Qatar
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Gerard Thompson
The University of Toledo
gerard.thompson@utoledo.edu

Abstract
In this paper, symmetries of the canonical geodesic equations of indecomposable nilpotent Lie groups of dimension five are constructed. For each case, the associated system of geodesics is provided. In addition, a basis for the associated Lie algebra of symmetries as well as the corresponding non-zero Lie brackets are listed and classified.

4. Traveling Waves in Discrete Models of Biological Populations with Sessile Stages

Ahlam Harish Alzahrani
University of Arkansas at Little Rock
ahalzahrani@ualr.edu

Abstract
This paper deals with the existence of traveling waves for a discrete model of biological population with sessile stages. We discuss the existence of traveling waves when the migration probability may not have density, or if it has density function, the density function may not be continuous. For this end, we impose some conditions that guarantee the monotone property of the evaluation operator, so that we use Monotone Iteration Method.

5. Classical Bernoulli Type Free Boundary Problems

Ashok Aryal
Minnesota State University Moorhead
ashok.aryal@mnstate.edu

Abstract
Free boundary problems deal with solving partial differential equations (PDEs) in a domain, a part of whose boundary is prior unknown; that portion of the boundary is called a free boundary. Free boundary problems are widely used in various applications. Bernoulli free boundary problem, the Stefan Problem, and the Obstacle Problems are some notable free boundary problems. In this talk, we will discuss some examples of the free boundary problems, its geometrical aspect, and the Bernoulli type free boundary problem for divergence form elliptic operator.

6. Modeling the Dependence of Atmospheric Pressure with Altitude using Caputo and Caputo-Fabrizio Fractional Derivatives

Muath Awadalla*
King Faisal University, Turkey
muathawadalla@gau.edu.tr

Yves Yameni Yannick
Eastern Mediterranean University, Cyprus
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Kinda Jamal Abuassba
Girne American University, Cyprus
Kinda.joudeh@gmail.com

Abstract
This article is concerned with the model describes the relationship between the atmospheric pressure with altitude by converting the ordinary initial value problems (classical model) to fractional value problems involving Caputo and Caputo-Fabrizio fractional derivatives of real order. We investigate the existence and uniqueness of the proposed fractional model when Caputo-Fabrizio derivative is used. The aim is to show, based on experimental data from a real experiment and by using the root-mean-square deviation technique that the fractional approach may lead to a better estimation for the parameters than the ordinary one. A comparison between the error rates of the classical, Caputo, and Caputo-Fabrizio is also introduced.


Yunxiang Bai
University of Louisiana at Lafayette
c00257292@louisiana.edu

Abstract
Generalized monotone method is a productive technique to prove the existence and approximate to the solution. In this work, we develop the generalized monotone method associated with coupled lower and upper solutions to solve for the nonlinear Caputo fractional impulsive differential equations.
8. An Efficient and Accurate High-Order Method in Application to Space-Fractional Reaction-Diffusion Systems with Nonhomogeneous Boundary Conditions

Harish Bhatt
Savannah State University
bhatt@ savannahstate.edu

Abstract
A major challenge in the numerical treatment of space fractional reaction-diffusion equations is the presence of nonlocality issues, which generates computational and numerical difficulties that have not been encountered in the context of the classical diffusion equations. Moreover, in the presence of nonlinearities, these difficulties are amplified with the need for efficient and accurate stable numerical methods. In this talk, we will introduce an unconditionally stable fourth-order method both in time and space directions, which is capable of removing the stiffness issues related to the fractional-order derivatives. The performance of the method in terms of accuracy and computational efficiency has been investigated by testing it on three numerical examples, including Brusselator and Gray-Scott models. Comparison of the numerical results obtained via the proposed method, RK4 method and modified ETDRK4 method exhibited that the proposed method is computationally more efficient and reliable than RK4 and modified ETDRK4 methods.

9. The Ideal 2D MHD Equations

Nicki Boardman
Oklahoma State University
nicki.boardman@ okstate.edu

Abstract
This talk presents recent work on the two-dimensional (2D) magnetohydrodynamic (MHD) equations with neither dissipation nor magnetic diffusion. Due to the nonlinear coupling between the evolution equations of the velocity and the magnetic field in the MHD system and the lack of dissipation, the question of global regularity for this system remains open. We will discuss recent work transforming the 2D system to a 1D system and our efforts to construct a particular instance of finite time blow-up in the 1D system.

10. Fluid-Structure Interactions: Control and Optimization

Lorena Bociu*
North Carolina State University
lebociu@ncsu.edu

Lucas Castle
Virginia Military Institute
Abstract

We focus on fluid-structure interactions (FSI) described by incompressible, viscous fluids coupled with elastic structures that move and deform inside them. Fluid-structure interactions have various medical and engineering applications, ranging from blood flow in stenosed arteries to the design of small-scale unmanned aircrafts. In most of the applications, the goal is the optimization or optimal control of the considered process. Specific examples include: minimizing turbulence, achieving given targets for fluid velocity or pressure, and minimizing the hydro-elastic pressure on the interface between the two environments. Therefore we consider PDE-constrained optimization and optimal control problems governed by moving boundary fluid-elasticity interactions. These interactions are highly nonlinear couplings of parabolic-hyperbolic type, described by a mismatch of regularity of the two solutions at the common interface. We discuss main challenges and describe the results that we obtained so far regarding the existence of optimal controls and the derivation of necessary optimality conditions.

11. Eigenfunctions of Quadratic Pencil Operators

Amin Boumenir
University of West Georgia
boumenir@westga.edu

Abstract

We give a new and direct proof of the celebrated Gasymov-Guseinov representation of the eigenfunctions of quadratic pencil operators defined by

\[-y''(x, \lambda) + 2\lambda p(x)y(x, \lambda) + q(x)y(x, \lambda) = \lambda^2 y(x, \lambda)\]

where \(p \in H^1_0(0,1)\) and \(q \in L^2(0,1)\). By using Paley-Wiener spaces, we show that \(y(x, \lambda) - \cos(x\lambda - a(x))\) belongs to the Paley-Wiener space \(PW_x\) where \(a\) is a certain antiderivative of \(p\). If \(p = 0\), then we obtain the well known Gelfand-Levitan theory. We will discuss applications of the Gasymov-Guseinov formula to the spectral theory of the quadratic pencil differential operator and the stability of evolution equations generated by it.

12. Evolutionary Stability of Ideal Free Dispersal under Spatial Heterogeneity
and Time Periodicity

Robert Stephen Cantrell
University of Miami
rsc@math.miami.edu

Abstract
Roughly speaking, a population is said to have an ideal free distribution on a spatial region if all of its members can and do locate themselves in a way that optimizes their fitness, allowing for the effects of crowding. Dispersal strategies that can lead to ideal free distributions of populations using them have been shown to exist and to be evolutionarily stable in a number of modeling contexts in the case of habitats that vary in space but not in time. Those modeling contexts include reaction-diffusion-advection models and the analogous models using discrete diffusion or nonlocal dispersal described by integro-differential equations. Furthermore, in the case of reaction-diffusion-advection models and their nonlocal analogues, there are strategies that allow populations to achieve an ideal free distribution by using only local information about environmental quality and/or gradients. We show that in the context of reaction-diffusion-advection models for time-periodic environments with spatially varying resource levels, where the total level of resources in an environment remains fixed but its location varies seasonally, there are strategies that allow populations to achieve an ideal free distribution. We also show that those strategies are evolutionarily stable. However, achieving an ideal free distribution in a time-periodic environment requires the use of nonlocal information about the environment such as might be derived from experience and memory, social learning, or genetic programming. This is joint work with Chris Cosner.

13. Mean Field Games with State Constraints

Rossana Capuani*
North Carolina State University
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Piermarco Cannarsa
University of Roma ”Tor Vergata”, Italy
cannarsa@mat.uniroma2.it

Pierre Cardaliaguet
Universite Paris-Dauphine (Paris IX), France
cardaliaguet@ceremate.dauphine.fr

Abstract
Mean Field Games (MFG) with state constraints are differential games with infinitely many agents, each agent facing a constraint on his state. In this case, the existence and uniqueness of Nash equilibria cannot be deduced as for unrestricted state space because, for a large set of initial conditions, the uniqueness of solutions to the minimization problem which is solved by each agent is no longer guaranteed. Therefore, we attack the problem by interpreting equilibria as measures in a space of arcs and we introduce the definition of mild solution for MFG with state constraints. More precisely, we define a mild solution as a pair \((u, m) \in C([0, T] \times \bar{\Omega}) \times C([0, T]); \mathcal{P}(\bar{\Omega})\), where
The aim of this talk is to provide a meaning of the PDE system associated with these games, the so-called Mean Field Game system with state constraints. For this, we will analyze the regularity of mild solution and we will show that it satisfies the MFG system in suitable point-wise sense. These results have been obtained in collaboration with Piermarco Cannarsa (Rome Tor Vergata) and Pierre Cardaliaguet (Paris-Dauphine).

14. Vanishing Relaxation Time Dynamics of the Jordan Moore-Gibson-Thompson (JMGT) Equation Arising in High Frequency Ultrasound

Sutthirut Charoenphon
The University of Memphis
schmphon@memphis.edu

Abstract
The (third-order in time) JMGT equation is a nonlinear (quasilinear) Partial Differential Equation (PDE) model introduced to describe the acoustic velocity potential in ultrasound wave propagation. One begins with the parabolic Westervelt equation governing the dynamics of the pressure in nonlinear acoustic waves. In its derivation from constitutive laws, one then replaces the Fourier law with the Maxwell-Cattaneo law, to avoid the paradox of the infinite speed of propagation. This process then gives rise to a new third time derivative term, with a small constant coefficient $\tau$, referred to as relaxation time. As a consequence, the mathematical structure of the underlying model changes drastically from the parabolic character of the Westervelt model (whose linear part generates a s.c, analytic semigroup) to the hyperbolic-like character of the JMGT model (whose linear part generates a s.c, group on a suitable function space). It is therefore of both mathematical and physical interest to analyze the asymptotic behaviour of hyperbolic solutions of the JMGT model as the relaxation parameter $\tau \geq 0$ tends to zero. In particular, it will be shown that for suitably calibrated initial data one obtains at the limit exponentially time-decaying solutions. The rate of convergence allows one then to estimate the relaxation time needed for the signal to reach the target. The interest in studying this type of problems is motivated by a large array of applications arising in engineering and medical sciences. These include applications to welding, lithotripsy, ultrasound technology, noninvasive treatment of kidney stones.

15. Convergence of a Particle Method and Global Weak Solutions for a Family of Evolutionary PDEs

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Abstract
In this talk, I will present global existence and uniqueness results for a family of fluid transport equations by establishing convergence results for the particle method applied to these equations.
The considered family of PDEs is a collection of strongly nonlinear equations, which yield traveling wave solutions and can be used to model a variety of flows in fluid dynamics. We apply a particle method to the studied evolutionary equations and provide a new self-contained method for proving its convergence. The latter is accomplished by using the concept of space-time bounded variation and the associated compactness properties. From this result, we prove the existence of a unique global weak solution in some special cases and obtain stronger regularity properties of the solution than previously established.

16. Wavelet Regularization for Ill-Posed Problems

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Abstract
We have considered the Laplace equation in an arbitrary-shaped domain and presented a numerical method by embedding the domain into a circular domain. This results in solving an inverse problem and the associated ill-conditioning is handled by wavelet regularization. In this talk, we will present our current results.

17. Existence of the Solution in-the-large for Caputo Fractional Reaction Diffusion Equation by Picard’s Method

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Abstract
We have developed Picard’s iterative method to prove the existence and uniqueness of the solution of the nonlinear Caputo fractional reaction diffusion equation in one dimensional space. The order of the fractional time derivative \( q \) is such that \( 0.5 \leq q \leq 1 \). The existence result has been proved by a priori assuming the solution is bounded. Thus, we refer to this method as existence of solution in the large. The method can be extended to the Caputo fractional reaction diffusion system also.

18. Some Bifurcation Results for Fractional Laplacian Problems

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Abstract
We use bifurcation theory to establish the existence of connected set of solutions of a fractional Laplacian problem satisfying Dirichlet type boundary condition on the exterior of the domain. We discuss the nodal properties of solutions on these connected sets and determine the direction of
bifurcation of these connected sets. Under additional assumptions, we establish the multiplicity of solutions near the resonance and the existence of solution in the resonant case. We also discuss anti-maximum principle, and solvability for the resonant case satisfying the so called Landesman-Lazer type condition.

19. Steklov Approximations of Solutions of Laplacian Boundary Value Problems

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Abstract  
Eigenfunction expansion methods have been studied in various ways to study solutions of PDEs. This talk will feature error estimates for approximation of solutions of Laplace’s equation with Dirichlet, Robin or Neumann boundary value conditions using the harmonic Steklov eigenfunctions. Based on the spectral theory of trace spaces the solutions are represented by orthogonal basis from normalized Steklov eigenfunctions. When the region is a rectangle, with explicit formulae for the Steklov eigenfunctions, both theoretical analysis and numerical experiments will introduce the efficiency and accuracy of the Steklov expansion methods in this talk.

20. Distributed Delay Effects on Coupled van der Pol Oscillators, and a Chaotic van der Pol-Rayleigh System with Parametric Forcing

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Abstract  
Distributed delays modeled by 'weak generic kernels' are introduced in two well-known coupled van der Pol systems, as well as a chaotic van der Pol-Rayleigh system with parametric forcing. The systems are closed via the 'linear chain trick'. Linear stability analysis of the systems and conditions for Hopf bifurcation that initiates oscillations are investigated, including deriving the normal form at bifurcation, and deducing the stability of the resulting limit cycle attractor. The value of the delay parameter $a = a_{Hopf}$ at Hopf bifurcation picks out the onset of Amplitude Death(AD) in all three systems, with oscillations at larger values (corresponding to weaker delay). In both van der Pol systems, the Hopf-generated limit cycles for $a > a_{Hopf}$ turn out to be remarkably stable under very large variations of all other system parameters beyond the Hopf bifurcation point, and do not undergo further symmetry breaking, cyclic-fold, flip, transcritical or Neimark-Sacker bifurcations. This is to be expected as the corresponding undelayed van der Pol systems are robust oscillators over very wide ranges of their respective parameters. Numerical
simulations reveal strong distortion and rotation of the limit cycles in phase space as the parameters are pushed far into the post-Hopf regime, and also reveal other features, such as how the oscillation amplitudes and time periods of the physical variables on the limit cycle attractor change as the delay and other parameters are varied. For the chaotic system, very strong delays may still lead to the cessation of oscillations and the onset of AD (even for relatively large values of the system forcing which tends to oppose this phenomenon). Varying of the other important system parameter, the parametric excitation, leads to a rich sequence of dynamical behaviors, with the bifurcations leading from one regime (or type of attractor) into the next being carefully tracked.

21. A Uniformly Sharp Convexity Result for Discrete Fractional Sequential Differences

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Abstract
We prove that a class of convexity-type results for sequential fractional delta differences is uniformly sharp. More precisely, we consider the sequential difference $\Delta_{\mu+\nu}^{\nu} \Delta_{a-\mu}^{\mu} f(t)$, for $t \in \mathbb{N}_{3+a-\mu-\nu}$, and demonstrate that there is a strong connection between the sign of this function and the convexity or concavity of $f$ if and only if the pair $(\mu, \nu)$ lives in a particular subregion of the parameter space $(0, 1) \times (1, 2)$.

22. Quasilinearization Method for RL Fractional Systems

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Abstract
We construct a generalized quasilinearization method to approximate the unique solution of the nonlinear Riemann-Liouville (RL) fractional system of equations of order $q$, where $0 < q < 1$. Monotone sequences of linear RL systems are constructed from lower and upper solutions, where the $t^{1-q}$ weighted sequences converge uniformly and quadratically to the weighted unique solution of the system.

23. Sensitivity of a Coupled Wind/Wave Model Using Energy Transfer Schemes for Growing Waves

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Abstract
Efficiently coupling meteorology and wave models is the first step in the simulation of ocean waves. In order to achieve this goal, it is important to improve coupling relationships and physically based forcing terms in the transport equations of the wave model. In this work, we investigate the impact of a wave-age dependent surface roughness on waves generated by winds of different strengths. We concentrated our efforts around the critical layer, the region where the real part of the complex wave speed is equal to the mean flow velocity as this region is at the center of the interpretation of growth waves. As it can be observed in nature, ocean waves travel in groups and are changing in amplitude with time. We also incorporate a recently derived expression of the energy transfer rate to investigate groups of waves growing and decaying with time under the influence of the surrounding wind field.

24. Inverse Source Problems for Wave Propagation

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Abstract
Source problems play an important and unique role in PDEs. More specifically, inverse source scattering problem arises in many areas of science. It has numerous applications to medical imaging and geophysics, acoustical and bio-medical industries, antenna synthesis, and material science. In particular, inverse source problem seeks the radiating source which produces the measured wave field. This research aims to provide a technique for recovering the source function of the Helmholtz equation and some classical system of PDEs from boundary data at multiple wave numbers when the source is compactly supported in an arbitrary bounded $C^2$ boundary domain, establish uniqueness for the source from the Cauchy data on any open non empty part of the boundary for arbitrary positive $K$, and increasing stability when wave number $K$ is getting large for a 2 and 3 dimensional general domain. Various studies showed that the uniqueness can be regained by taking multifrequency boundary measurement in a non-empty frequency interval $(0, K)$.

25. Role of Regulatory T Cells on a Tumor-Immune System with Immunotherapy

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Abstract
We develop a mathematical model to examine the role of regulatory T cells during immunotherapy with IL-2. The model consists of four ordinary differential equations describing the dynamics of the tumor cells, effector T cells, regulatory T cells, and IL-2. The goal is to study the role of regulatory T cells, especially how does the ratio of regulatory T cells and effector T cells impact the outcome of the treatment. Through a combination of analytical studies and numerical simulations, our model reveals regulatory T cells play a key role during the treatment.

26. Singular Reaction Diffusion Equations where a Parameter Influences the Reaction Term and the Boundary Condition (I)

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Abstract
We analyse positive solutions to the steady state reaction diffusion equation:

\[
\begin{aligned}
-u'' &= \lambda h(t)f(u); \quad (0, 1) \\
-du'(0) + \mu(\lambda)u(0) &= 0 \\
-u'(1) + \mu(\lambda)u(1) &= 0
\end{aligned}
\]

where \( \lambda > 0 \) is a parameter, \( d \geq 0 \) is a constant, \( f \) is a \( C^2 \) increasing function on \([0, \infty)\) such that \( f(0) = 0 \) and \( \lim_{s \to \infty} \frac{f(s)}{s} = 0 \), \( h \) is a \( C^1 \) nonincreasing function on \((0, 1)\) with \( h(1) > 0 \) and there exist constants \( d_0 > 0, \alpha \in [0, 1) \) such that \( h(t) \leq \frac{d_0}{t^\alpha} \) for all \( t \in (0, 1] \), and \( \mu \) is an increasing continuous function on \([0, \infty)\) such that \( \mu(0) \geq 0 \). We will discuss existence and multiplicity results via the method of sub-supersolutions. Further, we will discuss uniqueness results for \( \lambda \gg 1 \).

27. Existence of Solutions to Boundary Value Problems on Infinite Intervals

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Jesus Rodriguez
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Abstract
In this talk, we will analyze boundary value problems on infinite intervals subject to generalized boundary conditions. In particular, results are obtained for problems in the differential equation setting for a wide variety of problems. For such problems, we establish sufficient conditions for the existence of solutions as well as a qualitative description of solutions according to a parameter. Conditions for solvability are obtained by employing the Lyapunov-Schmidt procedure and an application of the implicit function theorem.

28. Characterizations of String Stability for Systems with Delays

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Abstract
String Stability plays a significant role in the design of adaptive cruise control systems and the stability of interconnected systems in general. Even though the notion of string stability has been studied in detail in the context of delay-free systems, the literature has limited work for delay systems. In this work, we provide two characterizations of string stability along with their theoretical and practical importance. One characterization leads to Lyapunov description of string stability that provides a versatile tool in the design of adaptive control systems. A physical interpretation, which will motivate the other characterization provides an important way to visualize string stability. The latter characterization provides a better understanding of the process of designing a safe automobile platooning.

29. A Model of Debt with Bankruptcy Risk and Currency Devaluation

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Abstract
We consider a system of Hamilton-Jacobi equations, arising from a stochastic optimal debt management problem in an infinite time horizon with exponential discount, modeled as a noncooperative interaction between a borrower and a pool of risk-neutral lenders. In this model, the borrower is
a sovereign state that can decide how much to devaluate its currency and which fraction of its income should used to repay the debt. Moreover, the borrower has possibility of going bankrupt at a random time and must declare bankruptcy if the debt reaches to a threshold $x^*$. When bankruptcy occurs, the lenders only recover a fraction of their capital. To offset the possible loss of part of their investment, the lenders buy bonds at a discounted price which is not given a priori. This leads to a nonstandard optimal control problem. We establish an existence result of solutions to this system and in turn recover optimal feedback payment strategy $u^*(x)$ and currency devaluation $v^*(x)$. In addition, the behavior of $(u^*, v^*)$ near 0 and $x^*$ is studied.

30. Backward Bifurcation in Vector-Borne Model with Direct Transmission

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Abstract
This paper deals with the study of time since infection structured vector born model with the direct transmission. The model is analyzed to investigate the dynamical behaviour of the system. Analysis of the existence and stability of equilibria reveals the existence of backward bifurcation i.e. where the disease-free equilibrium (DFE) coexists with the endemic equilibrium (EE) when the reproduction number $\mathcal{R}_0$ is less than unity. This aspect shows that in order to control vector borne disease, it is not sufficient to have reproduction number less than unity although necessary. Thus, the infection can persist in the population even if the reproduction number is less that unity. Numerical simulation is presented to see the bifurcation behaviour in the model. By taking the reproduction number as the bifurcation parameter, we find the system undergoes backward bifurcation at $\mathcal{R}_0 = 1$. Thus, the model has backward bifurcation and may have one or two positive endemic equilibrium when $\mathcal{R}_0 < 1$ and unique positive endemic equilibrium whenever $\mathcal{R}_0 > 1$.

31. Recent Advancements in Mathematical Finance

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Abstract
In recent years, major advancements in mathematical finance have grown out of the study of two parabolic partial differential equations, the Nobel Prize winning Black-Scholes stock option equation

(BS) \[ \frac{\partial u}{\partial t} = \frac{\sigma^2}{2} \frac{\partial^2 u}{\partial x^2} + r x \frac{\partial u}{\partial x} - ru \]
and the Cox-Ingersoll-Ross zero coupon bond equation

\[
\frac{\partial u}{\partial t} = \frac{\sigma^2}{2} x \frac{\partial^2 u}{\partial x^2} + (\beta x + \gamma) \frac{\partial u}{\partial x} - xu
\]

both on

\[(x, t) \in (0, \infty) \times [0, \infty)\]

with initial condition

\[u(x, 0) = u_0(x) \geq 0.\]

By studying these problems on suitable weighted sup norm Banach spaces, we show that the \((C_0)\)–semigroup governing the Black-Scholes equation is chaotic, and the \((C_0)\)–quasicontractive semigroup governing the Cox-Ingersoll-Ross equation admits a new type of Feyman-Kac representation formula (as a limit). We also study problems when the volatility, interest rate, etc. may be time dependent. This is joint work with various coauthors.

### 32. How Small Can the Gap Be between Eigenvalues of the Schrödinger Equation?

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Abstract  
I will report on recent work primarily with Zakaria El Allali about optimal bounds on the fundamental gap for Schrödinger equations on intervals and on quantum graphs, under side assumptions on the potential energy, especially that it is convex or of single-well form.

### 33. Painlevé VI, Isomonodromy, and Fredholm Determinants

Nathan Hayford  
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Abstract  
The Painlevé equations appear naturally in various problems in theoretical physics, combinatorics, and other related areas. Although their existence has been known for over a century, methods of solving, and moreover, exact solutions to these equations were not known until relatively recently. We discuss the isomonodromy method of solving the Painlevé VI equation, and show that the problem can be reduced to the computation of a Fredholm determinant.

### 34. Solutions for a Class of Fractional Laplacian Problems

Elliott Hollifield  
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Abstract
We discuss the existence of positive solutions to nonlinear fractional Laplacian problems with Dirichlet external condition. We use degree theory combined with a re-scaling technique to show the existence of positive weak solutions for a class of superlinear problem when the bifurcation parameter is small.

35. Solutions of GSQG Front Problems

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Abstract
We consider a family of patch-like solutions of generalized surface quasi-geostrophic (GSQG) equation, where the patch may be unbounded. We derive the equations of the contour dynamics under different geometrical situations and prove that the initial value problems have unique local smooth solutions. Under a smallness assumption on the initial data, with the help of the dispersive estimate, we are able to prove the global existence of the solutions for SQG front problem. This is a joint work with John Hunter and Jingyang Shu.

36. Polynomial Simulation of Functional Differential Equations with Delayed Argument

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Abstract
A simple computational approach will be developed for a family of differential equations in one independent variable with a single delayed argument in the vector field. These equations can be mapped into a system of ODEs of a finite size, a subsystem of which involves only the function controlling the deviating argument. Key features in addition to the simplicity include freedom from root finding techniques and developing a continuous approximation. The method will be established for state independent delays with real analytic initial data, and then extended to stiff equations and nonanalytic data. The philosophy will then be extended to handle state dependent delays and distributed delays. The differential equations can be nonlinear and may be retarded,
neutral or advanced. Conditions for convergence of the approximation are established, and results of some numerical experiments are reported to indicate the robustness of the approach.

37. Instantaneous Blowup, Old and New Results

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Abstract
Consider
\[
\frac{\partial u}{\partial t} = \Delta u + \frac{c}{|x|^2} u + f(x,t),
\]
where \( f \geq 0, u_0 \geq 0 \) and \((f,u_0) \neq 0\). Assume \( u_0 \) and \( f \) are such that a unique positive solution exists for all \( t \geq 0 \) if \( c = 0 \). Then for \( c \leq C^*(N) = \left(\frac{N-2}{2}\right)^2 \), many global (in time) solutions exist, but for \( c > C^*(N) \), no positive solution in the sense of distributions exists. In fact, if \( V(x) = c/|x|^2 \) is replaced by \( V_n(x) = \min\{V(x),n\} \) and if \( f(x,t) \) is replaced by \( f_n(x,t) = \min\{f(x,t),n\} \), and if \( u_n \) is the corresponding unique positive solution, then \( u_n(x,t) \to \infty \) as \( n \to \infty \) for all \( x \in \mathbb{R}^N, t > 0 \). This is instantaneous blowup (IBU). This 1984 theorem of Pierre Baras and Jerry Goldstein led to much additional research on singular linear and nonlinear parabolic PDE. We will discuss new proofs and new theorems, including IBU when \( \mathbb{R}^N \) is replaced by the Heisenberg group \( \mathbb{H}^N \), nonexistence of positive solutions (even locally in time) for certain nonlinear parabolic problems, and related topics, involving the Ornstein-Uhlenbeck equation and others. This is joint work with many coauthors.

38. Numerical Methods for Variable Order Differential Equations

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Abstract
We introduce an initial value problem of the variable order differential equation
\[
\frac{d^\alpha(t)y}{dt^{\alpha(t)}} = f(t,y), \quad m - 1 < \alpha(t) < m, \ m \in \mathbb{Z}^+; \quad y(0) = y_0,
\]
where the order of differentiation \( \alpha(t) \), a smooth function of the independent variable, is defined as the generalization of fractional derivatives and review some physical situations of interest in which such equations can model a complex phenomenon. Such variable order differential equations can be approached by using the formalism for Volterra integral equations of second kind with singular integrable kernel. We present numerical methods and solutions for particular cases, and discuss the asymptotic approach of the solutions towards the limiting classical integer order differential equation.
39. A New Predictive Analytical Model for Software Vulnerability Discovery Process

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Abstract
A software vulnerability is defined as a flaw that exists in computer resources or control that can be exploited by one or more threats. In this presentation, we examine the existing models on the subject area and propose a new time-based differential equation model. We apply the proposed model in cumulative quarterly vulnerability data for three Operating Systems: Mac OS X, Windows 7, and Linux Kernel. Our model performs significantly better when compared with the existing models in terms of fitting and prediction capabilities.

40. Hybrid Chebyshev Polynomial Scheme for Solving Elliptic Partial Differential Equations

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Abstract
We propose hybrid Chebyshev polynomial scheme (HCPS), which couples the Chebyshev polynomial scheme and the method of fundamental solutions into a single matrix system. This hybrid formulation requires solving only one system of equations and opens up the possibilities for solving a large class of partial differential equations. In this work, we consider various boundary value problems and, in particular, the challenging Cauchy-Navier equation. The solution is approximated by the sum of the particular solution and the homogeneous solution. Chebyshev polynomials are used to approximate a particular solution of the given partial differential equation and the method of fundamental solutions is used to approximate the homogeneous solution. Numerical results show that our proposed approach is efficient, accurate, and stable.

41. On the Principal Eigenvalue of a Biharmonic System

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Abstract
We prove the existence, positivity, simplicity, uniqueness up to nonnegative eigenfunctions, and isolation of the principle eigenvalue of a biharmonic system.
42. Effects of Time-Varying Impulses on Exponential Stability of Inertial BAM Neural Network with Mixed Time-Varying Delays

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Abstract
The present article is investigating the effects of time-varying impulses on exponential stability to a unique equilibrium point of inertial BAM neural networks with mixed time-varying delays. A suitable variable transformation is chosen to transform the original system into the system of first order differential equation. The fixed point theory of homeomorphism has been implemented to find the distributed delay-dependent sufficient condition which assured the system has a unique equilibrium point. In order to study the impulsive effects on stability problems, the time-varying impulses including stabilizing and destabilizing impulses are considered with the transformed system. Based on the matrix measure approach and the extended impulsive differential inequality for a time-varying delayed system, we have derived sufficient criteria in matrix measure form which ensure the exponential stability of the system towards an equilibrium point for two classes of activation functions. Further, different convergence rates of the system’s trajectories have been discussed for the cases of time-varying stabilizing and destabilizing impulses using the concept of an average impulsive interval. Finally, the efficiency of the theoretical results has been illustrated by providing two numerical examples.

43. Branching Patterns, Dessins and Rational Functions

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Abstract
Branching pattern gives combinatoric structure of a rational function; it does not guarantee the existence of the function. For example, there exists no rational function for the branching pattern (2^4), (2^4), (2, 3^2), but there exists a rational function for the branching pattern (2, 3^2), (2^4), (2, 3^2), namely: \[ \frac{4(x^2+2)}{x^2(4x^2-1)^3}. \]
For Riemann spheres (genus 0), there is a one-one correspondence between dessins, permutation triples, and belyi functions of degree n. We can use this correspondence to verify the existence of belyi functions for a given branching pattern. Furthermore, the correspondence can be extended to near belyi functions. Basic method to compute dessins of degree n involves the following two steps: (i) start from the dessin of degree 1, (ii) add an edge on all possible spots to find dessins of the next degree. This method has a huge growth of \[ \frac{(n-1)!(n+1)!}{2} \] which makes it impossible to compute all dessins of degree as small as 12 without imposing additional restrictions or constraints.
In this presentation we will discuss about an efficient way to compute dessins for a given branching pattern using multi-edge reduction method. The new approach is very fast and efficient on computing dessins, and thus, on proving the existence of belyi functions for a given branching pattern.

44. The Study of Numerical Method for Transient Heat Transfer in Cylindrical Living Tissue

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Abstract
Skin is an important organ which contains thermal sensors that take part in the thermoregulatory control. Perspiration, on the other hand appears in the skin surface due to hot environmental temperature and during the physical exercise. It plays a vital role by controlling the heat transfer in the human body. The human thermal comfort is affected by the body’s heat exchange mechanism conduction convection, radiation, and evaporation. The mode of heat transfer between the body and environment depends upon the human internal physiological phenomena, together with the boundary conditions. The main aim of this paper is to study a numerical solution of unsteady-State one dimensional Pennes’ bio-heat equation with appropriate boundary conditions. The solution is used to observe the temperature profiles at high and low atmospheric temperature, different thermal conductivities, and different heat transfer coefficients in the living tissue especially in the human body at the various time step. Various Physical and physiological factors across the cylindrical living tissue have been incorporated in the model.

45. Sufficient Conditions for Stability and Asymptotic Convergence of a PEEC Model Stable Linear Autonomous Neutral Functional Differential Equation with Nonlinear Perturbations

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Abstract
Sufficient conditions are given for the stability of a Partial Element Equivalent Circuit (PEEC) model stable linear autonomous Neutral Functional Differential Equation (NFDE) with nonlinear
perturbations. In addition, sufficient conditions are given for the solution of the perturbed NFDE to asymptotically converge to the solution of the original linear autonomous NFDE.

46. Fast Split-Radix and Radix-4 Discrete Cosine Transform Algorithms

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Abstract
The Discrete Fourier Transform (DFT) has a plethora of applications in applied mathematics and electrical engineering. Discrete Cosine Transform (DCT) is a real-arithmetic analogue of DFT. DCTs with orthogonal trigonometric transforms have been especially popular in recent decades due to their applications in digital video technology and high efficiency video coding. One can say that DCT is the key transform in image processing, signal processing, finger print enhancement, quick response code (QR code), multi-mode interface, etc.

In this talk, we first introduce sparse and scaled orthogonal factorization for the DCT and inverse DCT. Afterwards, we present fast split-radix and radix-4 DCT and inverse DCT algorithms. We show that the proposed algorithms attain the lowest theoretical multiplication complexity and arithmetic complexity for 8-point DCT II/III matrices. We perform execution time of the proposed algorithms while verifying the connection to the order of the arithmetic complexity. Finally, the language of signal flow graph representation of digital structures is used to describe potential for real-world circuit implementation.

47. Fluid-Viscoelastic Structure Interaction

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Abstract
We consider a fluid-structure interaction model consisting of the N-S equations coupled with a system of elastic equations. The interaction between fluid and structure is ubiquitous in nature, arising in several areas of biological, medical and engineering sciences. Consider a doughnut-like
domain: a fluid occupies the exterior sub-domain, while an elastic structure occupies the interior sub-domain. They are described by the corresponding evolution equations which present strong coupling at the interface between two domains. A key factor - a novelty over past literature - is that the structure equation includes a term defining strong damping at the interior. This affects the boundary conditions on the interface which lead to a highly unbounded “perturbation”- preventing standard methods developed for uncoupled structures to apply. Careful analysis of this effect along with the analysis of the pressure term contributed in N-S equations provides key technical - mathematical challenge. We establish several mathematical results describing the character of the overall evolution either free or else under the action of a control at the interface or at the exterior boundary.

**48. A Note on the Resolvent Estimates of the Damped Wave Equation via Observability Estimate**

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**Abstract**

In my talk the main object of study is the following observability estimate

\[
(-\Delta - \lambda)u = f \implies \|u\|_{L^2(\mathbb{R}^n)} \leq C\left(\frac{1}{\lambda} \left\| f \right\|_{L^2(\mathbb{R}^n)} + \|u\|_{L^2(\Omega)}\right),
\]

where \(\Omega \subset \mathbb{R}^n\) be nonempty set and \(\lambda \in \mathbb{R}\).

In one-dimension case, we proved this estimate hold for \(\alpha = -\frac{1}{2}\) with \(\Omega\) as 2\(\pi\) periodic set. In higher dimensions this estimate is true for \(\alpha = 0\) with \(\Omega\) as 2\(\pi\) periodic set (which is certainly not optimal).

I will also show that using the above observability estimates, we can derive resolvent estimate for damped wave types equations. The resolvent estimate gives the energy decay rate of the underline equation.

**49. Implicit Finite Difference Method for Pricing of Derivatives**

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**Abstract**

Parabolic partial differential equation arise in pricing of financial derivatives. Numerical methods such as finite difference methods and monte carlo methods are used to approximate solution of this equation. In this talk, the pricing of the derivatives using the implicit method will be discussed.
50. Dissipative Periodic and Chaotic Patterns to the KdV–Burgers and Gardner Equations

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Ronald Adams*
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Abstract
We investigate the KdV-Burgers and Gardner equations with dissipation and external perturbation terms by the approach of dynamical systems. The stability of the equilibrium point is considered, and Hopf bifurcations are investigated after a certain scaling that reduces the parameter space of a three-mode dynamical system which now depends only on two parameters. In the case of the KdV-Burgers, we find homoclinic chaos by using Shil’nikov’s theorem.

51. The Collapse of a Spherical Bubble in a Water Tank in Connection with Einstein’s Field Equations

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Abstract
In this talk an analysis of the Rayleigh–Plesset equation for a three dimensional vacuous bubble in water is presented. When the effects of surface tension are neglected we find the radius and time of the evolution of the bubble as parametric closed-form solutions in terms of hypergeometric functions. By including capillarity we show the connection between RP equation and Abel’s equation, and we present parametric rational Weierstrass periodic solutions for nonzero surface tension. We conclude by comparing the Rayleigh–Plesset equation with Einstein’s field equations for spatially curved Friedmann–Robertson–Walker cosmology with perfect fluid matter.

52. Modeling Zika

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Necibe Tuncer
Abstract
Zika is an infectious disease transmitted by Ae. aegypti and Ae. Albopictus mosquitoes species, which are found also in the US. Zika is endemic in Puerto Rico and has exhibited local transmission in Florida and Texas. Other routes of transmission of Zika are through sexual contact or from a mother to the fetus. In general Zika infection is mild but it can lead Guillain-Barré Syndrome in adults and to severe birth defects in newborns to mothers with Zika infection. We model Zika infection within the vector and the host. We consider six population-level models of Zika, which use various combinations of disease transmission (vector and direct) and infectious classes (asymptomatic and pregnant). Using cumulative incidences and cumulative pregnant incidences from the 2016 Zika outbreak in Florida, we test the models for structural and practical identifiability. We find that the models are structurally identifiable but that direct transmission rates are not practically identifiable from these data. Further, fixing the recovery rates improves overall identifiability. Elasticity analysis of the Reproduction number suggests that the mosquito-to-human ratio, mosquito life span and biting rate have the greatest potential of reducing the reproduction number of Zika. These observations imply that control measures reducing mosquito numbers, life span or biting rate would have the highest impact. This work is joint with: N. Tuncer, B. LaBarre, S. Payoute.

53. Existence Results for Nonlinear Perturbations of Asymmetric Spectrum with Weights

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Abstract
We consider the boundary value problem
\[
\begin{align*}
-\Delta u + c(x)u &= \alpha m(x)u^+ - \beta m(x)u^- + f(x, u); \quad x \in \Omega, \\
\frac{\partial u}{\partial n} + \sigma(x)u &= \alpha \rho(x)u^+ - \beta \rho(x)u^- + g(x, u); \quad x \in \partial \Omega,
\end{align*}
\]
where \((\alpha, \beta) \in \mathbb{R}^2\), \(c, m \in L^\infty(\Omega)\), \(\sigma, \rho \in L^\infty(\partial\Omega)\) and the nonlinearities \(f\) and \(g\) are bounded continuous functions. We prove existence theorems for both the resonance and nonresonance cases relative to the asymmetric Spectrum with weights. For the resonance case, we provide a sufficient condition, the so-called generalized Landesman-Lazer condition, for the solvability. The proofs are based on variational methods and rely strongly on the variational characterization of the Spectrum.

54. Convection in Coupled Fluid-Porous Media Systems

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Abstract
In superposed fluid-porous media systems, the ratio of the fluid height to the porous medium height exerts a significant influence on the behavior of the coupled system, most notably with its impact on resulting convection cells. Altering the depth ratio slightly can trigger a transition from full-convection where convection cells extent throughout the entire domain to fluid-dominated convection where cells occupy only the fluid region. With current interest surrounding superposed fluid-porous medium systems in numerous projects of industrial, environmental, and geophysical importance (oil recovery, carbon dioxide sequestration, contamination in sub-soil reservoirs, etc.), being able to predict the critical depth ratio where this convection shift occurs is particularly timely. Based on the critical Rayleigh numbers of the respective uncoupled domains, we propose a theory for predicting the depth ratio required for the transition from full- to fluid-dominated convection. With results from stability analyses and numerical simulations, we find good agreement between critical predicted depth ratios and actual values, especially in the small Darcy number limit.

55. Singular Reaction Diffusion Equations where a Parameter Influences the Reaction Term and the Boundary Condition (II)

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Abstract
We study the singular semipositone problem:

\[
\begin{cases}
-u'' = \lambda h(t)f(u); & (0, 1) \\
\quad u(0) = 0 \\
\quad u'(1) + \mu(\lambda)u(1) = 0
\end{cases}
\]

where \( \lambda > 0 \) is a parameter, \( f \) is a \( C^2 \) increasing function on \([0, \infty)\) such that \( f(0) < 0 \), \( \lim_{s \to \infty} f(s) = \infty \) and \( \lim_{s \to \infty} \frac{f(s)}{s} = 0 \). \( h \) is a \( C^1 \) nonincreasing function on \((0, 1]\) with \( h(1) > 0 \) and there exist constants \( d_0 > 0, \alpha \in [0, 1) \) such that \( h(t) \leq d_0 t^\alpha \) for all \( t \in (0, 1] \), and \( \mu \) is a continuous non-negative function on \([0, \infty)\) such that \( \mu(0) \geq 0 \). We will establish a unique positive solution for \( \lambda \gg 1 \).

56. A Constructive Solution to the Ornstein-Uhlenbech Equation on a Separable Banach Space of Infinite Dimension

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Abstract
Gill and Myers proved that every separable infinite-dimensional Banach space, denoted \( B \), has an isomorphic, isometric embedding in \( \mathbb{R}^\infty = \mathbb{R} \times \mathbb{R} \times \ldots \). They used this result and a method due to Yamasaki to construct a sigma-finite Lebesgue measure \( \lambda_B \) for \( B \) and defined the associated integral \( \int_B d\lambda_B \) in a way that equals a limit of finite-dimensional Lebesgue integrals. The objective of this talk is to apply this theory to developing a constructive solution to the Ornstein-Uhlenbech equation:

\[
\frac{\partial u(x,t)}{\partial t} = \Delta u(x,t) + x \cdot \nabla u(x,t), \quad u(x,0) = \phi(x)
\]

where \( x \in B, \phi \in C^2_0(B) \) and \( t \in [0, \infty) \). Our approach is constructive in the sense that the solution \( u(x,t) \) of above equation is expressible as an integral \( \int_B d\lambda_B \) which, by the aforementioned definition, equals a limit of Lebesgue integrals on Euclidean space as the dimension \( n \to \infty \). Thus with this theory we may evaluate infinite-dimensional quantities, such as the solution \( u(x,t) \), by means of finite-dimensional approximation.

57. Spectral Asymptotics of Laplacians Defined by Fractal Measures and Some Applications

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Abstract
We report some results concerning spectral asymptotics of fractal Laplacians defined one-dimensional self-similar measures with overlaps. We also discuss some applications of the theory, including heat kernel estimates and wave propagation speed. Part of this work is joint with Qingsong Gu, Jiaxin Hu, Wei Tang and Yuanyuan Xie.
58. Metric Entropy for Hyperbolic Conservation Laws

Tien Khai Nguyen
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Abstract
Inspired by a question posed by Lax in 2002, in recent years it has received an increasing attention the study on the metric entropy for nonlinear PDEs. In this talk, I will present recent results on the sharp estimates on the metric entropy for hyperbolic conservation laws in $L^1$. Estimates of this type could provide a measure of the order of resolution of a numerical method for the corresponding equation.

59. Tenth Order Compact Finite Difference Schemes for One Dimensional Helmholtz Equations using Neumann Boundary Condition

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Abstract
This paper is designed to derived sixth, eight and tenth order compact finite difference schemes for one dimensional Helmholtz equation using Neumann boundary condition. Numerical experiments was conducted to test the efficiency, accuracy and validity of the proposed shemes. Numerical results obtained from difference orders are compared and also with the exacts solution. Convergence and stability obtained and errors computed using $L_2$ norms. Results shows that the tenth order of accuracy is better than order eight and sixth order while the sixth order of accuracy is better than the fourth order.

60. Mathematical Model for Rabies Transmission and Control in Nepal

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Abstract
Rabies is a neglected tropical disease caused by Rhabdovirus and often transmitted to humans and animals through the bites of infected animals. Even though vaccines against rabies are available, rabies still remains a burden killing a significant number of humans as well as domestic and wild animals in many parts of the world, including Nepal. In this study, we develop a mathematical model to describe transmission dynamics of rabies in Nepal. In particular, an indirect interspecies transmission from jackals to humans through dogs, which is relevant to the context of Nepal, is one of the novel features of our model. Using our model with some parameters estimated from human rabies
data, we calculated the basic reproduction number ($R_0$) for Nepal, and performed sensitivity analysis to identify that the dog-related parameters are primary contributors to $R_0$. We analyze the role of intraspecies and interspecies transmission between dog and jackal population in the persistence of rabies in Nepal. We found that even though intraspecies basic reproduction numbers of both dogs ($R_{D0}$) and jackals ($R_{J0}$) are less than 1, the rabies epidemic may still occur ($R_0 > 1$) due to interspecies transmission. Our results show that, along with dogs, jackals also play an important role in the persistence of rabies in Nepal. We also discussed the insufficiency of currently practiced intervention strategies: pre-exposure vaccines for dogs and post-exposure vaccines for exposed humans to control the human rabies in Nepal. In addition, we presented the impact of other intervention strategies such as dog sterilization, dog culling and jackal bait vaccination on rabies transmission in Nepal.

61. Lyapunov-Type Inequality and Eigen Value Estimate for a Fractional Problem with Hilfer Derivative

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Abstract
In this paper, we establish the Lyapunov-type inequality for fractional boundary value problem of order $\alpha$, $3 < \alpha \leq 4$ defined in terms of Hilfer fractional derivative. We obtain Green’s function for the corresponding boundary value problem and use a property of the Green’s function to obtain the Lyapunov-type inequality. We use this inequality in two applications; first, to find lower bound for the lowest eigenvalue, and second, to find the domain in which certain combination of Mittag-Leffler functions have no zeros. We further use the Cauchy-Schwarz inequality to improve the lower bound for the smallest eigenvalue and stretch the domain in which certain combinations of Mittag-Leffler functions have no real zeros.

62. Random Attractor for Stochastic Hindmarsh-Rose Equations with Multiplicative Noise

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Abstract
The global pullback dynamics of stochastic Hindmarsh-Rose equations with multiplicative noise in neurodynamics is investigated in this work. The existence of a random attractor for this random dynamical system is proved through the exponential transformation and uniform estimates showing the pullback absorbing property and the pullback asymptotically compactness of this stochastic cocycle.

63. An Isospectral Flow on Banded Matrices and its Optimality

Krishna P. Pokharel
Abstract
In this talk, we discuss an isospectral flow in the space of matrices, which deforms any given real banded matrix with a simple real spectrum to a symmetric matrix. We prove that if the initial condition $A_0$ is banded matrix with lower bandwidth $p = 2$ and upper bandwidth $q = 0$ with simple real spectrum and second subdiagonal elements different from zero, then its omega-limit set is a pentadiagonal symmetric matrix isospectral to $A_0$ and it has the same sign pattern in the second subdiagonal elements as the initial condition $A_0$. We provide some simulation results to highlight some aspects of this nonlinear system. As an application, we prove that this flow provides the solution of an infinite-time horizon optimal control problem.

64. Special-Functions Solutions of Burgers’ Equation

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Abstract
The inviscid Burgers equation is part of an “integrable hierarchy” of PDEs, also known as dispersionless KP. Work by A.V. Zabrodin (2001) gave a geometric solution that uses moments of an analytic curve, but no explicit formulas; A. Boyarsky, A. Marshakov, O. Ruchayskiy, P. Wiegmann and A. Zabrodin (2001) identified one case in which the curve is algebraic and the solution can be made explicit. In joint work with Shigeki Matsutani (2008), explicit solutions were found, that use Klein’s sigma function on any curve that is a cyclic cover of the Riemann sphere; these were extended (2019) to any smooth curve in Weierstrass canonical form. The independent variables are integrals on the Jacobian of the curve. The talk will present the definition of the sigma function and the explicit solutions, and review the Zabrodin construction to pose the question of the relationship between the two.

65. Generalized Monotone Iterative Techniques for Caputo Fractional IVP with an Application to Biological Models

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Abstract
We will begin this presentation with the definition and important properties of the Caputo fractional derivative. Next, we describe the main problem and define two different sets of coupled lower and upper solutions of a Caputo fractional differential equation with initial condition of order $q, 0 < q < 1$. The forcing function is the sum of an increasing function and a decreasing, which is common in classical applications such as the logistic model. Then, we develop two monotone iterative techniques, one corresponding to each set of lower and upper solutions, which consist of
sequences that converge uniformly and monotonically to minimal and maximal solutions of the IVP. Finally, we present an application example that illustrates our results.

66. Optimization of the Penalty Parameter for the Dual-Wind Discontinuous Galerkin Methods on a Prototypical Second Order PDE.

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Abstract
A discontinuous Galerkin (DG) finite-element interior calculus is used as a common framework to describe various DG approximation methods for second-order elliptic problems. The dual-wind discontinuous Galerkin method (DWDG) has been shown to be stable and consistent for a wide range of penalty parameter values, including zero, for second order elliptic problems under certain mesh conditions. In this presentation, we will present the results of numerical experiments on various second order elliptic problems with varying penalty parameters that show the choice of zero for the penalty parameter is an optimal choice for application.

67. Penalization of Dirichlet Optimal Control Problem for Magneto Hydrodynamics

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Abstract
We study the approximation of unsteady magnetohydrodynamic equations with Dirichlet control by equations with penalized Neumann control. We prove the existence of optimal solutions to the penalized control problem. We prove the convergence of solutions of penalized control problem to the corresponding solutions of the Dirichlet control problem, as the penalty parameter goes to zero. First order order necessary and second order sufficient optimality condition are developed. Numerical results are provided.

70. Investigating the Impact of Supercritical Fluid Properties on the Turbulence
Physics of the Round Turbulent Jet

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Abstract
Supercritical Carbon Dioxide (sCO\(_2\)) is a promising working fluid for many applications across a wide range of industries. One such example is in advanced cycles, including those for power generation (e.g., Brayton cycle), because of increased power density. While research on experimental engineering has revealed interesting physical aspects of supercritical fluids, open questions remain about the fundamental physics of these flows. In this investigation, we study sCO\(_2\) jets to gain a better understanding of the underlying physics and the influence of non-ideal variations in the physical properties of supercritical fluids. We study the impact of a cubic equation of state on turbulent flow physics using PeleC, a first-principles simulation code that leverages second order finite volume methods with adaptive mesh refinement. We implement the Piecewise Parabolic Method with a standard second order Runge-Kutta method to approximate our solutions. The system of partial differential equations is closed using the Soave-Redlich-Kwong equation of state. Special attention is paid to the stability of coupling the cubic equation of state with the Navier-Stokes equations. Simulations for the sCO\(_2\) turbulent round jet are performed at 330 K and 10 MPa, conditions that are above the critical point of 304.25 K and 7.39 MPa, where new insight is needed for engineering design. We then examine velocity and Reynolds stress profiles at different downstream locations and contrast these with established theory. We explore cases with differing jet and ambient fluid temperatures to study the effect of thermal property variation in supercritical fluids.

69. Factorization of Fractional Quantum Oscillators

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Stefan C. Mancas
Abstract
The factorization method, a technique that has been used extensively for eigenvalue problems from the beginning of quantum mechanics and revived with the advent of supersymmetric quantum mechanics during the 1980s is used here for the eigenvalue problem of fractional oscillators characterized by Levy indices $\alpha$ in the range of values that still allows to consider these nonlocal oscillators as quantum-mechanical ones, i.e., $\alpha \in (1, 2]$. The wavefunctions of these oscillators are linear combinations of generalized hypergeometric functions, with sub-Gaussian ground states for any $\alpha < 2$, and Gaussian only for $\alpha = 2$, which corresponds to the standard quantum harmonic oscillator case.

70. Well-Posedness Results on Non-Linear Classical Field Theories in Physics

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Abstract
In this talk we will review some results from the theory of partial differential equations in order to approach the study and analysis of the initial value problem of certain classical field theories in Physics, particularly in the framework of General Relativity. After reviewing the pseudodifferential theory of first order systems and some results on hyperbolicity, we will see how certain nonlinear extensions of classical theories in Physics such as Electromagnetism and Hydrodynamics can be turned to be hyperbolic, and under which requirements it is possible to guarantee a well-posed initial value formulation.

71. The Time Periodic Solution of the Burgers Equation on the Half-Line and an Application to Steady Streaming

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Abstract
The evolution of large amplitude Tollmien-Schlichting waves in boundary layer flows over wavy surfaces is considered for two-dimensional disturbances which are locally periodic in time and space. Consideration is given to both large $Re >> 1$ and $Re \sim O(1)$ Reynolds numbers using asymptotic methods. The large Reynolds number analysis is valid for oscillatory two-dimensional turbulent boundary layer. In both cases the phase equation approach shows that the wavenumber and frequency will develop shocks or other discontinuities as the disturbance evolves. It is shown that the evolution of constant frequency/wavenumber disturbances and their modulational instability is controlled by Burgers equation at finite Reynolds number and by a new integro-differential evolution equation at large Reynolds numbers. The Burgers equation is formulated on the half line, using
Fokas' method, which provides a simple model of the above phenomenon. The physical situation corresponds to the solution of the Dirichlet problem on the half-line, which decays as $x \to \infty$ and which is time periodic. It is shown that the Dirichlet problem, where the usual prescription of the initial condition is now replaced by the requirement of the time periodicity, yields a well posed problem. Furthermore, it is also shown that the solution of this problem tends to the “inner” and “outer” solutions obtained by the perturbation expansions. For the large Reynolds number case the evolution equation points to the development of a spatially localized singularity at a finite time. The three-dimensional generalizations of the evolution equations is also given for the case of weak spanwise modulations.

### 72. Reduced Fertility and Asymptotics of the Logistic Model

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**Fabio Milner**
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**Abstract**
This logistic model includes three age groups. Juveniles do not reproduce, and old individuals reproduce at a reduced rate. Pairings between individuals of different fertility rates may lead to multiple equilibria and bi-stability: the total population converges to different limits depending on its initial size. The behavior is correlated with transition rates from high to low fertility groups and with the frequency of pairing among the various groups of reproduction level. The proportions of adults at equilibrium are roots of a quartic polynomial, alternating sinks and saddles. Necessary and sufficient conditions for the existence of bi-stability are provided for a simplified model.

### 73. Convergence of the Method of Finite Differences in Optimal Control for Second Order Elliptic PDEs

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**Abstract**
Optimal control of the general boundary value problems in a bounded Lipschitz domain for the linear second order uniformly elliptic PDEs with bounded measurable coefficients is considered. Control parameter is the density of sources, and the cost functional is the $L_2$ norm declination of the weak solution of the elliptic problem from measurement along the boundary or subdomain. The optimal control problems are fully discretized using the method of finite differences. Two types of discretization of the elliptic boundary value problem depending on Dirichlet or Neumann type boundary condition are introduced. We prove the convergence of the sequence of finite-dimensional discrete optimal control problems to the original problems both with respect to the cost functional and the control. The methods of the proof are based on energy estimates in discrete Sobolev spaces, weak compactness and convergence of interpolations of solutions of discrete elliptic problems, and delicate estimation of the cost functional along the sequence of interpolations of the minimizers of the discrete optimal control problems.

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### 74. Positive Solutions for a Derivative Dependent $p$–Laplacian Equation with Riemann-Stieltjes Integral Boundary Conditions

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**Abstract**

In this talk, we will discuss the existence of two non-trivial positive solutions to a class of boundary value problems (BVP), involving a $p$–Laplacian, of the form:

$$(\Phi_p(x'))' + g(t)f(t,x,x') = 0, \quad t \in (0,1),$$

$$x(0) - ax'(0) = \alpha[x],$$

$$x(1) + bx'(1) = \beta[x],$$

where $\Phi_p(x) = |x|^{p-2}x$ is a one dimensional $p$-Laplacian operator with $p > 1$, $a, b$ are real constants. Here $\alpha, \beta$ are given by Riemann-Stieltjes integrals

$$\alpha[x] = \int_0^1 x(t) dA(t), \quad \beta[x] = \int_0^1 x(t) dB(t),$$

where $A$ and $B$ are functions of bounded variations. We will use the fixed point index theory to establish our results.

---

### 75. Numerical Solutions of 2D Boussinesq Equations with Fractional Dissipation

**Ramjee P. Sharma**  
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**Abstract**
In this presentation we will talk about the numerical computations of 2D Boussinesq equations with fractional dissipation using parallel pseudospectral method. Given smooth initial data, whether the solutions of the system with all the possible values of the parameters develop finite time singularity or not is yet to be known. We will present the evolution of geometry of the level curves, energy spectra and associated norms of two major quantities involved in the system. The solutions were computed for different values of parameters. Some of our computational results strongly indicate potential singularity in finite time suggesting a need for further investigations.

76. Uniqueness of Positive Radial Solutions for a Class of Infinite Semipositone $p$–Laplacian Problems in a Ball

Ratnasingham Shivaji
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Abstract
We prove uniqueness of positive radial solutions to the $p$–Laplacian problem

$$\begin{cases} -\Delta_p u = \lambda f(u) \text{ in } \Omega, \\ u = 0 \text{ on } \partial\Omega, \end{cases}$$

where $\Delta_p u = \text{div} (|\nabla u|^{p-2} \nabla u)$, $p \geq 2$, $\Omega$ is the open unit ball in $\mathbb{R}^N$, $N > 1$, $f : (0, \infty) \to \mathbb{R}$ is concave, $p$–sublinear at $\infty$ with infinite semipositone structure at 0, and $\lambda$ is a large parameter.

77. A Statistical Learning Model Utilized to Validate a Market Hypothesis

Timothy Smith
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Abstract
In finance, regression models have been frequently utilized to predict the value of an asset based on its underlying traits. In prior work we built a regression model to predict the value of the S&P 500 based on macroeconomic which were selected through a process of general subjective knowledge followed by model optimization. In the present work the method of statistical machine learning is utilized to decide what predictors are to be used within the model. In addition, a well known market hypothesis “the 5 year moving average death cross” is mathematical validated and a scheme to relate those critical time periods to particular values of the regression predictors is outlined. In addition, closing comments are made to address future research ideas and how these cyclical market patterns could be related to a nonlinear PDE, most likely hyperbolic, and how modern machine learning evolutionary nonlinear fits could be utilized to discover such a PDE.

78. Search for Cycles of Long Length in Discrete Dynamical Systems

Alexander M. Stokolos*
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Abstract

We explore the problem of stabilization of unstable periodic orbits of large period in discrete nonlinear dynamical systems. This work proposes the generalization of predictive control method for resolving the stabilization problem. Our method embodies the development of control method proposed by B.T. Polyak. The control we propose uses a linear (convex) combination of iterated functions. With the proposed method auxiliary, the problem of robust cycle stabilization for various cases of its multipliers localization is solved.

79. Quenching Problem for Two Dimensional Time Fractional Reaction-Diffusion Equation via Lower Solution Method

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Abstract

We study the quenching problem for time Caputo-fractional reaction-diffusion equation with a nonlinear reaction term in a two-dimensional rectangular domain. In this work, we prove local existence and the quenching of the solution of the solution of Caputo fractional ordinary differential equation and Caputo fractional reaction-diffusion equation with a nonlinear reaction term in finite time. We establish the condition for quenching for the solution of the fractional ordinary differential equation and fractional reaction-diffusion equation. We also provide the upper bound for the quenching time of the solution of fractional ordinary and reaction-diffusion equation. The study of quenching behavior of the solution of fractional differential equation relies on the quenching behavior of the solution of integer order reaction-diffusion equation and method of upper and lower solution.

80. Hardware Accelerated Fast FDTD of Time Dependent Maxwell’s Equations on Xilinx RF SoC

Nilan Udayanga*
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Abstract
Electromagnetics, which govern the fields of wireless communications, radar, and remote sensing, are fully described using four first-order PDEs known as Maxwell’s Equations. The finite-difference time-domain (FDTD) algorithm invented by Yee in 1966 operates on a discrete space-time staggered grid-pair for the electric and magnetic fields, and solutions are obtained via leapfrog update equations. The field of computational electromagnetics makes extensive use of the FDTD algorithm for modeling involving various types of antennas, microwave filters, circuits, aerospace vehicles, and wireless systems. For accurate and dispersion-less solution, the discretization of the spatial and temporal variables require a high degree of over-sampling that is much higher than what is demanded by the Nyquist Sampling Theorem, in order for the discrete domain update equations to represent the behavior of a continuous linear PDE system. The highly-oversampled nature of FDTD results in high computational complexity and therefore long execution times on high-performance computing systems. Hardware acceleration is a technique to accelerate the computation of FDTD using application-specific integrated digital processor arrays that are custom designed for implementing FDTD without using any software at all. The hard-wired parallel computation allows very good acceleration compared to state-of-art computing solutions based on high-performance compute servers, GPU realizations, and cloud computing techniques. The talk reports on a hardware accelerator that supports real-time operation on a Xilinx RF SoC device. Comparison with GPUs are provided (interim results show better than x100).
Equations

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Abstract
Using several properties of the polynomial splines, we first discuss the discretization of the first order spatial derivatives at different nodal points. Using such discretization we derive a scheme that is fourth order accurate for the numerical solution of parabolic PDEs on a non-uniform mesh. Finally, we discuss the stability theory and compute the numerical results to illustrate the reliability of the scheme.

82. The Stochastic Permanence of Disease and the Stationary Behavior for a Class of Nonlinear SEIRS Epidemic Models

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Abstract
An interesting topic for investigation in the study of stochastic differential equation epidemic models involving Brownian motion perturbations concerns the permanence of disease and existence of a stationary behavior for the state of the stochastic process over time. Conditions for the permanence of the disease hold the key to understand the endemic behavior of the disease; a stationary distribution leads to knowing the statistical properties of the disease over long time. This talk discusses a class of Itô stochastic differential equation SEIRS epidemic models for vector-borne diseases e.g. malaria. Lyapunov functional techniques and some local martingale characterizations are applied to find persistence conditions for the disease by examining the average behavior of all sample paths of the system over time. Moreover, the conditions for the existence of a stationary distribution for the SEIRS system are presented. Furthermore, the stationary distribution is explored numerically.

83. Existence of Solutions for a Second Order Discrete Boundary Value Problem with Mixed Periodic Boundary Conditions

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Abstract
In this talk, a second order discrete boundary value problem with a pair of mixed periodic boundary conditions is considered. Sufficient conditions on the existence and multiplicity of solutions are obtained by using variational methods. A particular Banach space and an associated functional are presented to overcome the asymmetry of the mixed periodic boundary conditions. Examples are also given to illustrate the applications of the main result.
84. Introducing Challenging Modeling Problems Early with Chebfun Add-Ons for MATLAB

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Abstract
Early introduction of challenging and meaningful problems can significantly enhance learning. In a beginning ODEs course, many instructors shy away from “messy modeling problems” because they often require significant numerical work to get meaningful results. But with the chebfun add-ons for MATLAB, much of the numerical “overhead” for solving these problems can be lessened or even eliminated. I will briefly demonstrate the use of the chebfun add-ons and then discuss some examples of challenging modeling exercises which can be completed as lab projects in a first ODEs course with minimal additional support beyond the typical course material. (The chebfun add-ons are open-source and available freely from their authors at www.chebfun.org).

85. SIS and SIR Epidemic Models on Time Scales

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Abstract
In this talk, we formulate SIR (susceptible-infected-recovered) and SIS (susceptible-infected-susceptible) epidemic models with time-dependent coefficients on time scales to unify and extend continuous and discrete models. We derive exact solutions to these models by the approach of the Bernoulli dynamic equation and discuss the asymptotic behavior of susceptibles and infectives. Examples on different time scales are presented to illustrate the results.

86. The Impact of Time Delay in a Tumor Model

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Abstract

We consider a free boundary tumor growth model with a time delay in cell proliferation and study how time delay affects the stability and the size of the tumor. The model consists of a coupled system of an elliptic equation, a parabolic equation and an ordinary differential equation to describe the cell location under the presence of time delay, with the tumor boundary as a free boundary. A parameter \( \mu \) in the model is proportional to the “aggressiveness” of the tumor. It is proved that there exists a unique classical radially symmetric stationary solution \((\sigma^*, p^*, R^*)\) which is stable for any \( \mu > 0 \) with respect to all radially symmetric perturbations [S. Xu, Q. Zhou, and M. Bai, Qualitative analysis of a time-delayed free boundary problem for tumor growth under the action of external inhibitors]. However, under non-radially symmetric perturbations, we prove that there exists a critical number \( \mu_* \) such that if \( \mu < \mu_* \) then the stationary solution \((\sigma^*, p^*, R^*)\) is linearly stable; whereas if \( \mu > \mu_* \) then the stationary solution is unstable. It is actually unrealistic to expect the problem to be stable for large tumor aggressiveness parameter, therefore our result is more reasonable. Furthermore, it is also proved by the authors that adding the time delay in the model would result in a larger tumor, and if \( \mu \) is larger, then the time delay would have a greater impact on the size of the tumor.

87. Two Regularization Models for Computed Tomography Image Reconstruction from Limited Projection Data

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Abstract

Computed tomography (CT) has been widely applied in medical imaging and industry for over decades. CT reconstruction from limited projection data is of particular importance. The total variation or \( \ell_1 \)-norm regularization has been widely used for image reconstruction in computed tomography (CT). Images in computed tomography (CT) are mostly piece-wise constant so the gradient images are considered as sparse images. The \( \ell_0 \)-norm of the gradients of an image provides a measurement of the sparsity of gradients of the image. However, the \( \ell_0 \)-norm regularization problem is NP hard. In this talk, we present two new models for CT image reconstruction from limited-angle projections. In one model we propose the smoothed \( \ell_0 \)-norm and \( \ell_1 \)-norm regularization using the nonmonotone alternating direction algorithm. In the other model we propose a combined \( \ell_1 \)-norm and \( \ell_0 \)-norm regularization model for better edge preserving.
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