Contents

1 Schedules

1.1 Schedule Overview

Friday, March 20		
7:00 PM - 9:00 PM	Reception (and registration)	Heritage Hall Lobby
Saturday, March 21		
7:30 AM - 9:30 AM	Registration	Heritage Hall Lobby
8:00 AM - 8:20 AM	Welcoming Remarks by Dean Palazzo and Opening Remarks by SIAM SEAS President Hongqiu Chen	Heritage Hall 102
8:20 AM - 9:20 AM	IP1: Hilbert Sixth Problem: Newton, Boltzmann and Navier-Stokes, Tai-Ping Liu, *Stanford University and Academia Sinica*	Heritage Hall 102
9:20 AM - 9:50 AM	Coffee Break	Heritage Hall Lobby
9:50 AM - 11:50 AM Concurrent Sessions	MS1: Accurate and efficient time integration methods for unsteady PDEs I	Education Bldg 147
	MS2: Inverse Problems I	Heritage Hall 121
	MS3: Inverse Problems and Imaging I	Heritage Hall 124
	MS4: Multiscale Modeling in Cancer: from genotype to phenotype I	Heritage Hall 104
	MS5: Nonlinear PDEs of Conservation Laws and Fluid Mechanics I	Heritage Hall 125
	MS6: Numerical Approximation of Partial Differential Equations I	Education Bldg 133
	MS7: Optimal Control, Optimization, Inverse Problems and Numerical Simulations with Applications I	Education Bldg 129
	MS8: Recent Advances in Statistical Learning Theory	Education Bldg 134
	MS9: Tensor Computations and Applications I	Education Bldg 130
	MS10: Variational models and their fast algorithms in mathematical imaging	Education Bldg 146
	CS1: Contributed Session I	Education Bldg 135
11:50 AM - 1:00 PM	Lunch (boxed lunch provided)	Heritage Hall Lobby
12:30 PM - 12:55 PM	Student Career Panel: How to succeed in graduate school	Heritage Hall 106
1:00 PM - 2:00 PM	IP2: Discovery of Graphs for Designs of Supercomputer Networks, Yuefan Deng, *Stony Brook University*	Heritage Hall 102

02:15 PM - 04:15 PM Concurrent Sessions	MS11: Accurate and efficient time integration methods for unsteady PDEs II	Education Bldg 147
	MS12: Inverse Problems II	Heritage Hall 121
	MS13: Inverse Problems and Imaging II	Heritage Hall 124
	MS14: Multiscale problems and methods in numerical simulations	Education Bldg 134
	MS15: Multiscale Modeling in Cancer: from genotype to phenotype II	Heritage Hall 104
	MS16: Nonlinear PDEs of Conservation Laws and Fluid Mechanics II	Heritage Hall 125
	MS17: Numerical Approximation of Partial Differential Equations II	Education Bldg 133
	MS18: Optimal Control, Optimization, Inverse Problems and Numerical Simulations with Applications II	Education Bldg 129
	MS19: Tensor Computations and Applications II	Education Bldg 130
	CS2: Contributed Session II (Student Session)	Heritage Hall 106
	CS3: Contributed Session III	Education Bldg 135
4:15 PM - 4:45 PM	Coffee Break (poster set-up)	Heritage Hall Lobby
4:45 PM - 6:30 PM	Poster Session and Special Session (10-minute talks of MS student speakers) (pizza provided)	Heritage Hall Lobby/106
Sunday, March 22		
7:30 AM - 9:30 AM	Registration	Heritage Hall Lobby
8:00 AM - 9:00 AM	IP3: How to control flutter arising in flow structure interactions, Irena Lasiecka, *University of Memphis*	Heritage Hall 102
9:00 AM - 10:00 AM	IP4: Hybrid Constrained Iterative Methods for Inverse Problems, James Nagy, *Emory University*	Heritage Hall 102
10:00 AM - 10:30 AM	Coffee Break	Heritage Hall Lobby
10:30 AM - 12:30 PM Concurrent Sessions	MS20: Accurate and efficient time integration methods for unsteady PDEs III	Education Bldg 147
	MS21: Inverse Problems III	Heritage Hall 121
	MS22: Nonlinear differential equations	Heritage Hall 124
	MS23: Nonlinear PDEs of Conservation Laws and Fluid Mechanics III	Heritage Hall 125
	MS24: Numerical Approximation of Partial Differential Equations III	Education Bldg 133
	MS25: Optimal Control, Optimization, Inverse Problems and Numerical Simulations with Applications III	Education Bldg 129
	CS4 Contributed Session IV	Education Bldg 146
	CS5 Contributed Session V	Education Bldg 130
	CS6 Contributed Session VI	Education Bldg 135
12:30 PM - 1:30 PM	Lunch (boxed lunch provided)	Heritage Hall Lobby
1:30 PM - 2:00 PM	Closing Remarks and Award Ceremony	Heritage Hall Lobby

1.2 Section Schedules and Details

Saturday, 08:20 AM - 09:20 AM

Tai-Ping Liu	**Location: Heritage Hall 102**
Hilbert Sixth Problem: Newton, Boltzmann and Navier-Stokes	Chair: Yanni Zeng

We focus on the aspect of Hilbert Sixth Problem concerning the kinetic theory for gases. There are two parts to this Problem. The first part is the derivation of the Boltzmann equation from the Newtonian interacting particle systems, and the second part concerns the relation between the Boltzmann equation and the fluid dynamics. Both involves some form of averaging. The derivation of the Boltzmann equation is both philosophically and mathematically challenging and is historically important. For instance, it is not clear how the probabilistic element comes in and the scaling involved in the averaging is very subtle. The relation between the Boltzmann equation and the fluid dynamics is a rich subject; the Boltzmann equation is known to be able to explain observed phenomena that the traditional fluid equations such as Navier-Stokes cannot. We will discuss these topics, survey the recent progresses and raise open problems.

Saturday, 09:50 AM - 11:50 AM

Accurate and Efficient Time Integration Methods for Unsteady PDEs I		**Education Bldg 147**
Organizers: Xinfeng Liu and Shan Zhao		
09:50 - 10:20	Lili Ju	Fast and Accurate Algorithms for Simulating Coarsening Dynamics of Cahn-Hilliard Equations
10:20 - 10:50	Amanda Diegel	Analysis of a Second-Order in Time Mixed Method for the Cahn-Hilliard Equation
10:50 - 11:20	Zhu Wang	Time Domain Decomposition Methods for Forward-and-Backward PDEs
11:20 - 11:50	Chuan Li	Continuous Development of a Matched Alternative Direction Implicit (ADI) Method for Solving Parabolic Interface Problems
Inverse Problems I		**Heritage Hall 121**
Organizers: Roberto Triggiani and Rudi Weikard		
09:50 - 10:20	Ricardo Weder	High and Low Energy Analysis and Levinson's Theorem for the Selfadjoint Matrix Schrödinger Operator on the Half Line
10:20 - 10:50	Shitao Liu	Determining a Magnetic Schrödinger Operator from Partial Data in an Infinite Slab
10:50 - 11:20	Maxim Zinchenko	Chebyshev Polynomials on Finite Gap Sets
Inverse Problems and Imaging I		**Heritage Hall 124**
Organizers: Junshan Lin and Hao-Min Zhou		
09:50 - 10:20	Yunmei Chen	A Fast Accelerated Bundle Level Method for Large Scale Convex Optimization
10:20 - 10:50	Zuhair Nashed	TBA
10:50 - 11:20	Peijun Li	Inverse Elastic Surface Scattering with Near-Field Data
11:20 - 11:50	Daniel Onofrei	Active Manipulation of Fields

Multiscale Modeling in Cancer: From Genotype to Phenotype I		**Heritage Hall 104**
Organizers: Thierry Colin and Hassan Fathallah-Shaykh		
09:50 - 10:20	Nidhal Bouaynaya	Nonlinear Networks Dynamics and Opposite Effects of Wnt5a on Motility in Melanomas
10:20 - 10:50	Etienne Baratchart	Modeling of in Vivo Experiments of Metastatic Initiation and Tumor-Tumor Spatial Interactions
10:50 - 11:20	Olivier Saut	Data Assimilation in Lung Metastases Modeling: Towards Patient Calibrated Models Using Imaging Devices
11:20 - 11:50	Dimah Dera	Level Set Segmentation Using Non-Negative Matrix Factorization with Application to MRI
Nonlinear PDEs of Conservation Laws and Fluid Mechanics I		**Heritage Hall 125**
Organizers: Tao Luo, Robin Young and Yanni Zeng		
09:50 - 10:20	Robin Young	Asymptotic Expansion of Hyperbolic Evolution Operators
10:20 - 10:50	Ralph Saxton	Periodic Solutions to Sign-Changing Liouville Equations
10:50 - 11:20	Yanni Zeng	Some Recent Results for Hyperbolic Balance Laws
11:20 - 11:50	Geng Chen	Wellposedness of Variational Wave Equation
Numerical Approximation of Partial Differential Equations I		**Education Bldg 133**
Organizers: Vince Ervin, Yanzhao Cao and Hong Wang		
09:50 - 10:20	Yanzhi Zhang	Schrödinger Equation with Fractional Laplacians
10:20 - 10:50	Feng Bao	A Meshfree Implicit Filter for Solving Nonlinear Filtering Problems
10:50 - 11:20	Hong Wang	An Indirect Spectral Method for Fractional Differential Equations
11:20 - 11:50	Song Chen	The Numerical Approximation of a Generalized Bio-Convection Flow
Optimal Control, Optimization, Inverse Problems and Numerical Simulations with Applications I		**Education Bldg 129**
Organizer: Ana-Maria Croicu		
09:50 - 10:20	Xiang Wan	Global Well-Posedness and Uniform Stability of a Nonlinear Thermo-Elastic PDE System
10:20 - 10:50	Stephen Guffey	Optimal Control of a Parabolic PDE System Arising in Wound Healing
10:50 - 11:20	Catalin Trenchea	Constrained Optimization for Random Data Identification Problems
11:20 - 11:50	Mehdi Vahab	Numerical Methods for Fractional Order Systems
Recent Advances in Statistical Learning Theory		**Education Bldg 134**
Organizer: Qiang Wu		
09:50 - 10:20	Jun Fan	Functional Linear Regression Using Gaussian Kernel
10:20 - 10:50	Yiming Ying	Analysis of Some Online Learning Algorithms with Kernels
10:50 - 11:20	Ning Zhang	A Refined Algorithm of Sliced Inverse Regression
Tensor Computations and Applications I		**Education Bldg 130**
Organizers: Carmeliza Navasca and Shannon Starr		
09:50 - 10:20	Christina Glenn	Symmetric Outer Product Decomposition for Tensors
10:20 - 10:50	Shuchin Aeron	Tensors as Linear Operators: Implications for Multiway Data Analytics
10:50 - 11:20	Xiaofei Wang	Low Rank Approximation of Tensor from the Viewpoint of Sparsity

Variational models and their fast algorithms in mathematical imaging Education Bldg 146 Organizer: Wei Zhu		
09:50 - 10:20	Sung Ha Kang	Alternating Direction Method of Multiplier for Elastica Denoising
10:20 - 10:50	Xiaojing Ye	Fast Decentralized Gradient Descent Method
10:50 - 11:20	Daozhi Han	A Decoupled Unconditionally Stable Numerical Scheme for the Cahn-Hilliard-Hele-Shaw System
11:20 - 11:50	Wei Zhu	A Variational Model for Shape from Shading
Contributed Session I **Education Bldg 135** Chair: James L. Moseley		
09:50 - 10:20	James L. Moseley	The Discrete Agglomeration Model:The Moment Problem for the Autonomous Quadratic Kernel
10:20 - 10:50	Israel Ncube	Stability in a Distributed Delay Differential Equation
10:50 - 11:20	Howard Richards	Metastable Decay of Nearest-Neighbor Ising Ferromagnets in the Hyperbolic Plane
11:20 - 11:50	Tomer Lancewicki	Multi-Target Shrinkage Estimation for Covariance Matrices
Student Career Panel **Heritage Hall 106** UAB SIAM Student Chapter		
12:30 - 12:55	Caleb Moxley, Christina Glenn and Alzaki Fadlallah	Student Career Panel on ”How to succeed in graduate school”

Saturday, 1:00 PM - 2:00 PM

Yuefan Deng **Location: Heritage Hall 102**
Discovery of Graphs for Designs of Supercomputer Networks Chair: Ian Knowles

Supercomputers, capable of performing 10^{16} floating-point operations per second (34 PFlops), connect millions of computing cores by complex networks. In the case of the Tianhe-2, 3.12 million cores require networking. In 2019 when Exascale systems emerge, more than 100 million cores will need to be connected and the traditional intuition with simple networks will unlikely survive to produce scalable systems. To advance, we must leverage on the, active and young, graph theory, conceptually and computationally, to seek for new breakthrough in network topologies and routing protocols.

For a regular graph of N vertices each with k edges, we note it as Nkk, e.g., for a regular graph with $N = 32$ vertices each with $k = 5$ edges, we note it as $32k5$. After discovering a series of perfectly optimized (in terms of the graph diameter and average vertex-vertex edge distances) regular graphs with $N = 4, 8, 16, 32$ for the appropriate corresponding node degrees $k = 2, 3, 4, 5$, we embed them to generate much larger composite hierarchical graphs, e.g., $16k4 \otimes 32k5$ or $8k3 \otimes 16k4 \otimes 32k5$. These embedded graphs, with tens of thousands of vertices, are used to design supercomputer interconnection networks. With the metrics we introduced to measure the network-performance-relevant properties of graphs, we compare our quasi-optimal embedded graphs with many widely adopted networks for supercomputers.

Saturday, 02:15 PM - 04:15 PM (02:15 PM - 04:45 PM for extended sessions)

Accurate and Efficient Time Integration Methods for Unsteady PDEs IIEducation Bldg 147 Organizers: Xinfeng Liu and Shan Zhao		
02:15 - 02:45	Yingjie Liu	Further Study of Back and Forth Error Compensation and Correction Method for Advection and Hamilton-Jacobi Equations
02:45 - 03:15	Wei Guo	A High Order Time Splitting Method Based on Integral Deferred Correction for Semi-Lagrangian Vlasov Simulations
03:15 - 03:45	Taras Lakoba	Long-Time Numerical Integration of the Generalized Nonlinear Schrödinger Equation with Time Steps Exceeding the Instability Threshold
03:45 - 04:15	Xinfeng Liu	Compact Implicit Integration Factor Method for a Class of High Order Differential Equations
Inverse Problems II **Heritage Hall 121** Organizers: Roberto Triggiani and Rudi Weikard		
02:15 - 02:45	Ian Knowles	The Inverse Oilfield Problem
02:45 - 03:15	Roberto Triggiani	Global Uniqueness and Stability of an Inverse Problem for the Schrödinger Equation on a Riemannian Manifold via One Localized Boundary Measurement
03:15 - 03:45	Sergey Avdonin	Control and Invrse Problems for a String
Inverse Problems and Imaging II **Heritage Hall 124** Organizers: Junshan Lin and Hao-Min Zhou		
02:15 - 02:45	Sung Ha Kang	Illusory Shapes via Corner Fusion
02:45 - 03:15	Jianfeng Cai	A Fast Algorithm for Super-Resolution of Spectrally Sparse Signals
03:15 - 03:45	Yuanchang Sun	Mathematical Modeling and Methods of Signal Separations
03:45 - 04:15	Lars Ruthotto	Numerical Methods for Hyperelastic Image Registration
Multiscale Modeling in Cancer: From Genotype to Phenotype II **Heritage Hall 104** Organizers: Thierry Colin and Hassan Fathallah-Shaykh		
02:15 - 02:45	Elizabeth Scribner	Effects of Anti-Angiogenesis on Glioblastoma Growth and Migration: Model to Clinical Predictions
02:45 - 03:15	Pedro Lowenstein	Mechanisms of Glioma Formation: Exploring Glioma Growth Through Dialectic Biological-Computational Approaches
03:15 - 03:45	Thierry Colin	Modeling of the Resistance to Treatments for Gastro-Intestinal Stromal Tumors
03:45 - 04:15	Hassan Fathallah-Shaykh	Motility Determines Growth, Recurrence, and Treatment Response: Insights From a Mathematical Model of GBM
Multiscale Problems and Methods in Numerical Simulations **Education Bldg 134** Organizer: Seong Jun Kim		
02:15 - 02:45	Yoonsang Lee	Multi-Scale Data Assimilation for Turbulent Systems
02:45 - 03:15	Christina Frederick	A Methods for Multiscale Inverse Problems
03:15 - 03:45	Duk-soon Oh	An Iterative Substructuring Method for Problems Posed in H(div)
03:45 - 04:15	Seong Jun Kim	A Multiscale Computation for Highly Oscillatory Dynamical Systems Using an EMD-Type Method

Nonlinear PDEs of Conservation Laws and Fluid Mechanics II		**Heritage Hall 125**
Organizers: Tao Luo, Robin Young and Yanni Zeng		
02:15 - 02:45	Shuang Miao	Shock Formations for 3-Dimensional Wave Equations
02:45 - 03:15	Huihui Zeng	Global Solutions to the Gas-Vacuum Interface Problem with Physical Singularity of Compressible Euler Equations with Damping
03:15 - 03:45	Yilun Wu	On Rotating Star Solutions to the Euler-Poisson Equations – Inner Hard Core and Non-Isentropy
03:45 - 04:15	Tao Luo	Global Regularity and Long Time Dynamics for a Vacuum Free Boundary Problem of Viscous Gaseous Stars
Numerical Approximation of Partial Differential Equations II		**Education Bldg 133**
Organizers: Vince Ervin, Yanzhao Cao and Hong Wang		
02:15 - 02:45	Javier Ruiz-Ramirez	Darcy Fluid Flow with Deposition
02:45 - 03:15	Lunji Song	A Multi-Domain Spectral IPDG Method for the Helmholtz Equation
03:15 - 03:45	Hans-Werner van Wyk	Multilevel Sampling with Adaptive Mesh Refinement
03:45 - 04:15	Shuhan Xu	Error Estimation for Quasi-Newtonian Fluid-Structure Interaction Problems
Optimal Control, Optimization, Inverse Problems and Numerical Simulations with Applications II		**Education Bldg 129**
Organizer: Ana-Maria Croicu		
02:15 - 02:45	Cécile Dobrzynski	Curved Meshing for High Reynolds Flows Solved Using High Order Framework
02:45 - 03:15	Chaoxu Pei	Two Discontinuous Galerkin Spectral Element Cut-Cell Methods for the Stefan Problem
03:15 - 03:45	Yongjin Lu	Uniform Stabilization to a Nontrivial Equilibria of a Fluid Structure Interaction Model
Tensor Computations and Applications II		**Education Bldg 130**
Organizers: Carmeliza Navasca and Shannon Starr		
02:15 - 02:45	Luke Oeding	Equations for the Fifth Secant Variety of Segre Products of Projective Spaces
02:45 - 03:15	Shannon Starr	Eigenvectors of Non-Hermitian Random Matrices
03:15 - 03:45	Alexandra Fry	Compressed Sensing in a Multilinear Sparse System of Genomic Interactions
03:45 - 04:15	Carmeliza Navasca	Random Projections for Low Multilinear Rank Tensors

Contributed Session II (Student Session) Chair: Alzaki Fadlallah		**Heritage Hall 106**
02:15 - 02:40	Alzaki Fadlallah	Linear elliptic systems with nonlinear boundary conditions without Landesman-Lazer conditions
02:40 - 03:05	Mohammad H Akanda	A few model problems as symmetric positive systems
03:05 - 03:30	Muhammad Mohebujjaman	Numerical analysis and testing of a fully discrete, decoupled algorithm for MHD in Elsasser variable
03:30 - 03:55	Rachel Grotheer	Application of the Reduced Basis Method to the Forward Problem of Hyperspectral Diffuse Optical Tomography
03:55 - 04:20	Ali Darwish	Method for Comparing Saliency Maps in Computer Vision
04:20 - 04:45	Serdar Cellat	owards a Diagnostic Tool for Facial Dysmorphia
Contributed Session III Chair: Sirani M. Perera		**Education Bldg 135**
02:15 - 02:45	Sirani M. Perera	Signal Flow Design Approach to Orthogonal Radix-2 DCT-DST Algorithms
02:45 - 03:15	Nguyen Hoang	A fast algorithm for computing integration matrices for spectral methods
03:15 - 03:45	Hyunju Kim	Computation of Energy Release Rate Using Non-Uniform Rataional B-Spline Geometrical Mapping Method with Multiple Patches
03:45 - 04:15	Mahmoud DarAssi	Sedimentation and Thermophoresis Effects in the Presence of Convection in Colloidal Suspensions

Saturday, 04:50 PM - 05:30 PM

Special Session Chair: Alzaki Fadlallah and Eric Larson		**Heritage Hall 106**
04:50 - 05:00	Xiang Wan	Global Well-Posedness and Uniform Stability of a Nonlinear Thermo-Elastic PDE System
05:00 - 05:10	Javier Ruiz Ramirez	Darcy fluid flow with deposition
05:10 - 05:20	Etienne Baratchart	Modeling of in vivo experiments of metastatic initiation and tumor-tumor spatial interactions
05:20 - 05:30	Amanda Diegel	Analysis of a Second-Order in Time Mixed Method for the Cahn-Hilliard Equation

Sunday, 08:00 AM - 09:00 AM

Irena Lasiecka	**Location: Heritage Hall 102**
How to Control Flutter Arising in Flow Structure Interactions	Chair: Carmeliza Navasca

An appearance of flutter in oscillating structures is an endemic phenomenon. Most common causes are vibrations induced by the moving flow of a gas (air, liquid) which is interacting with a structure. Typical examples include: turbulent jets, vibrating bridges, oscillating facial palate in the onset of apnea. The intensity of the flutter depends heavily on the speed of the flow (subsonic, transonic or supersonic regimes). Thus, reduction or attenuation of flutter is one of the key problems in aeroelasticity with application to a variety of fields including aerospace engineering, structural engineering, medicine and life sciences.

Mathematical models describing this phenomenon involve coupled systems of partial differential equations (Euler Equation and nonlinear plate equation) with interaction at the interface - which is the boundary surface of the structure. The aim of this talk is to present a mathematical theory describing: (1) qualitative properties of the resulting dynamical systems (existence, uniqueness and robustness of weak solutions), (2) asymptotic stability and associated long time behavior that includes the study of global attractors, (3) feedback control strategies aiming at the elimination or attenuation of the flutter.

Since the properties of the flutter depend heavily on the speed of the flow (subsonic, transonic or supersonic), it is natural that the resulting mathematical theories will be very different in the subsonic and supersonic regimes. In fact, supersonic flows are known for depleting ellipticity from the corresponding static model. Thus, both wellposedness of finite energy solutions and long time behavior of the model have been open questions in the literature. The results presented include: (1) Existence, uniqueness and Hadamard wellposedness of finite energy solutions; (2) Existence of global and finite dimensional attracting sets for the elastic structure in the absence of any mechanical dissipation; (3) Strong convergence to multiple equilibria for the subsonic model subjected to a frictional damping imposed on the structure. As a consequence, one concludes that the supersonic flow alone (without any dissipation added to the elastic structure) provides some stabilizing effect on the plate by reducing asymptotically its dynamics to a finite dimensional structure. However, the resulting "dynamical system" may be exhibiting a chaotic behavior. In the subsonic case, instead, a feedback control which provides a sufficient damping of the structure eliminates asymptotically the flutter.

Sunday, 09:00 AM - 10:00 AM

James Nagy	**Location: Heritage Hall 102**
Hybrid Constrained Iterative Methods for Inverse Problems	Chair: Carmeliza Navasca

Linear systems that arise in large scale inverse problems are very challenging to solve. In addition to the problem being large scale, the underlying mathematical model is often ill-posed, which results in highly ill-conditioned coefficient matrices. Noise and other errors in the measured data can be highly magnified in computed solutions. Regularization methods are often used to overcome this difficulty. In this talk we describe hybrid regularization approaches, which combine matrix factorization methods with iterative solvers that can be efficient for large scale problems. Applications from image processing will be used to illustrate the effectiveness of hybrid methods.

Sunday, 10:30 AM - 12:30 PM

Accurate and Efficient Time Integration Methods for Unsteady PDEs III **Education Bldg 147**		
Organizers: Xinfeng Liu and Shan Zhao		
10:30 - 11:00	Xiaofeng Yang	Some Energy Stable Schemes for Phase Field Model With Moving Contact Lines
11:00 - 11:30	Yanzhi Zhang	Split-Step Method for Nonlinear Schr̈odinger Equations
11:30 - 12:00	Yulong Xing	Discontinuous Galerkin Methods for the Shallow Water Equations with ADER-DT Time Stepping
12:00 - 12:30	Shan Zhao	Fast Operator Splitting Algorithms for Biomolecular Solvation Analysis
Inverse Problems III **Heritage Hall 121**		
Organizers: Roberto Triggiani and Rudi Weikard		
10:30 - 11:00	canceled	
11:00 - 11:30	Alexander Bukhgeym	Carleman Formulas and Inverse Problems
11:30 - 12:00	Rudi Weikard	Solving the Camassa-Holm Equation by Inverse Scattering
Nonlinear Differential Equations **Heritage Hall 124**		
Organizer: Hongqiu Chen		
10:30 - 11:00	Jerry L. Bona	Ill-Posedness of Some Water Wave Models
11:00 - 11:30	Hongqiu Chen	Initial-Boundary Value Problem for the BBM-Equation
11:30 - 12:00	Ohannes Karakashian	Local Discontnuous Galerkin Methods for the Korteweg-de Vries Equation
12:00 - 12:30	Hassan Fathallah-Shaykh	Global Asymptotic Stability in a Model of Biological Networks
Nonlinear PDEs of Conservation Laws and Fluid Mechanics III **Heritage Hall 125**		
Organizers: Tao Luo, Robin Young and Yanni Zeng		
10:30 - 11:00	Katarzyna Saxton	Non-Strictly Hyperbolic Systems, Singularities and Bifurcation
11:00 - 11:30	Allen Tesdall	Further Results on Irregular Weak Reflectiong
11:30 - 12:00	Alexey Miroshnikov	On the Properties of Weak Solutions Describing Dynamic Cavitation in Nonlinear Elasticity
12:00 - 12:30	Greg Lyng	Spectral and Nonlinear Stability of Viscous Detonation Waves

Numerical Approximation of Partial Differential Equations III Organizers: Vince Ervin, Yanzhao Cao and Hong Wang		Education Bldg 133
10:30 - 11:00	Zhu Wang	Time Domain Decomposition Methods for Forward-and-Backward PDEs
11:00 - 11:30	Hoang Tran	ANALYSIS OF QUASI-OPTIMAL POLYNOMIAL APPROXIMATIONS FOR PARAMETERIZED PDES WITH DETERMINISTIC AND STOCHASTIC COEFFICIENTS
11:30 - 12:00	Jinhong Jia	Recent Developments of Fast Methods for FPDEs
12:00 - 12:30	Su Yang	A Fast Numerical Method for Nonlocal Models
Optimal Control, Optimization, Inverse Problems and Numerical Simulations with Applications III Organizer: Ana-Maria Croicu		**Education Bldg 129**
10:30 - 11:00	Michael Pokojovy	Analysis and Numerics for an Age- and Sex-Structured Population Model
11:00 - 11:30	Philippe Laval	Lotka-Volterra/Gompertz Competition Model for Tumor Growth
11:30 - 12:00	Thomas Robacker	Parameter Estimation Techniques Applied to Stochastic Models
12:00 - 12:30	Ana-Maria Croicu	Mathematical Modeling of 2014 Ebola Virus Outbreak
Contributed Session IV Chair: Koffi Fadimba		**Education Bldg 146**
10:30 - 11:00	Koffi Fadimba	Error Estimates for a Regularization of a Formulation of the Porous Medium Equation
11:00 - 11:30	Thinh Kieu	Two-phase Generalized Forchheimer Flows in Porous Media
11:30 - 12:00	Jonas Holdeman	On the Physics of Incompressible Fluids
12:00 - 12:30	Khalid Alammar	Effect of Round Cavities on Flow and Heat Transfer Characteristics in Converging Pipes: A Numerical Study
Contributed Session V Chair: Mikhail Khenner		**Education Bldg 130**
10:30 - 11:00	Daniel Fong	Modeling of Ischemia Reperfusion and Postconditioning
11:00 - 11:30	Emre Esenturk	On the Coffee Stain Problem
11:30 - 12:00	Mikhail Khenner	Mathematical model of electromigration-driven evolution of the surface morphology and composition for a bi-component solid film
12:00 - 12:30	Nick Kirby	Step-flow stability in the presence of electromigration during evaporation
Contributed Session VI Chair: James Lambers		**Education Bldg 135**
10:30 - 11:00	James Lambers	High-Order Time-Stepping through Rapid Estimation of Block Gaussian Quadrature Nodes
11:00 - 11:30	Ogugua Onyejekwe	The Application of Homotopy Analysis Method for the Solution of Time-Fractional Diffusion Equation with A Moving Boundary
11:30 - 12:00	Hashim Saber	A Model Reduction Algorithm for Simulating Sedimentation Velocity Analysis
12:00 - 12:30	Zurab Kiguradze	One Nonlinear Model Based on Maxwell System
12:30 - 1:00	Temur Jangveladze	On One System of Nonlinear Multi-dimensional Partial Differential Equations

2 Minisymposia

Accurate and Efficient Time Integration Methods for Unsteady PDEs

Organizer(s): Xinfeng Liu, Shan Zhao

Saturday	09:50AM - 11:50AM	HH106
Saturday	02:15PM - 04:15PM	HH106
Sunday	10:30AM - 12:30PM	HH106

Inverse Problems

Organizer(s): Roberto Triggiani, Rudi Weikard

Saturday	09:50AM - 11:20AM	HH121
Saturday	02:15PM - 03:45PM	HH121
Sunday	10:30AM - 12:00PM	HH121

Inverse Problems and Imaging

Organizer(s): Junshan Lin, Hao-Min Zhou

Saturday	09:50AM - 11:50AM	HH124
Saturday	02:15PM - 04:15PM	HH124

Multiscale Modeling in Cancer: From Genotype to Phenotype

Organizer(s): Thierry Colin, Hassan Fathallah-Shaykh

Saturday	09:50AM - 11:50AM	HH104
Saturday	02:15PM - 04:15PM	HH104

Multiscale Problems and Methods in Numerical Simulations

Organizer(s): Seong Jun Kim

Saturday	02:15PM - 04:15PM	EB134

Nonlinear Differential Equations

Organizer(s): Hongqui Chen

Sunday	10:30AM - 12:30PM	HH124

Nonlinear PDEs of Conservation Laws and Fluid Mechanics

Organizer(s): Tao Luo, Robin Young, Yanni Zeng

Saturday	09:50AM - 11:50AM	HH125
Saturday	02:15PM - 04:45PM	HH125
Sunday	10:30AM - 12:30PM	HH125

Numerical Approximation of Partial Differential Equations

Organizer(s): Vince Ervin, Yanzhao Cao, Hong Wang

Saturday	09:50AM - 11:50AM	EB133
Saturday	02:15PM - 04:15PM	EB133
Sunday	10:30AM - 12:30PM	EB133

Optimal Control, Optimization, Inverse Problems and Numerical Simulations with Applications

Organizer(s): Ana-Maria Croicu

Saturday	09:50AM - 11:50AM	HH126
Saturday	02:15PM - 03:45PM	HH126
Sunday	10:30AM - 12:00PM	HH126

Recent Advances in Statistical Learning Theory

Organizer(s): Qiang Wu

Saturday	09:50AM - 11:20AM	EB134

Tensor Computations and Applications

Organizer(s): Carmeliza Navasca, Shannon Starr

Saturday	09:50AM - 11:20AM	EB131
Saturday	02:15PM - 04:15PM	EB131

Variational Models and Their Fast Algorithms in Mathematical Imaging

Organizer(s): Wei Zhu

Saturday	09:50AM - 11:50AM	EB146

3 Abstracts

MS1: Accurate and Efficient Time Integration Methods for Unsteady PDEs I

Fast and Accurate Algorithms for Simulating Coarsening Dynamics of Cahn-Hilliard Equations

Lili Ju, *University of South Carolina*

The coarsening dynamics in a binary mixture can be modeled by the celebrated Cahn-Hilliard equations. To perform efficient and accurate long time integration, we develop a fast and stable high-order numerical algorithm for solving Cahn-Hilliard equations. The spatial discretization is carried out by compact difference methods while the time integration is done through a high-order exponential time difference multistep approach. We demonstrate the effectiveness of the new algorithm by numerical experiments and study computationally the coarsening kinetics corresponding to different choices of the diffusion mobility.

Analysis of a Second-Order in Time Mixed Method for the Cahn-Hilliard Equation

Amanda Diegel, *University of Tennessee*

In this talk, I present the analysis of an unconditionally stable, second-order-in-time numerical scheme for the Cahn-Hilliard equation in two and three space dimensions. We prove that our two-step scheme is unconditionally energy stable and unconditionally uniquely solvable. Furthermore, we show that the discrete phase variable is bounded in $L^\infty(0,T;L^\infty)$ and the discrete chemical potential is bounded in $L^\infty\left(0,T;L^2\right)$, for any time and space step sizes, in two and three dimensions, and for any finite final time T. We subsequently prove that these variables converge with optimal rates in the appropriate energy norms in both two and three dimensions.

Time Domain Decomposition Methods for Forward-and-Backward PDEs

Zhu Wang, *University of South Carolina*

The forward-and-backward partial differential equation system always appears in the optimal control and optimization problems. It is appealing to solve such a system directly since a single solve suffices to determine the optimal states, adjoint states, and controls. However, this approach is computationally expensive. In this talk, we present several time domain decomposition methods, which are based on a decomposition of the time domain into smaller subdomains, and are suited for implementation on parallel computer architectures. The effectiveness of these algorithms are verified by numerical tests

Continuous Development of a Matched Alternative Direction Implicit (ADI) Method for Solving Parabolic Interface Problems

Chuan Li, *University of Alabama, Tuscaloosa*

A matched Alternate Direction Implicit method (ADI) was introduced by Dr. Shan Zhao recently aiming at delivering an efficient and stable method for solving parabolic interface problems with general physical interface conditions. This work continues the development of this scheme and improves it for handling more complex geometries and interface conditions. Numerical results obtained by the coupling of this matched ADI method and various time steppers are reported in this talk as well.

MS2: Inverse Problems I

High and Low Energy Analysis and Levinson's Theorem for the Selfadjoint Matrix Schrödinger Operator on the Half Line

Ricardo Weder, *Universidad Nacional Autnoma de Mexico*

The matrix Schrödinger equation with selfadjoint matrix potential is considered on the half line with the general selfadjoint boundary condition. For integrable potentials, the high energy asymptotics are established for the Jost and the scattering matrices. Under the additional assumption that the potential has a first moment, it is shown that the scattering matrix is continuous at zero energy, and a explicit formula is provided for its value. Levinson's theorem is also derived.

Determining a Magnetic Schrödinger Operator from Partial Data in an Infinite Slab

Shitao Liu, *Clemson University*

In this talk we consider an inverse boundary value problem with partial data in an infinite slab for the magnetic Schrödinger operator with bounded magnetic potential and electric potential. We show that the magnetic field and the electric potential can be uniquely determined, when the Dirichlet and Neumann data are given on either different boundary hyperplanes or on the same boundary hyperplanes of the slab.

Chebyshev Polynomials on Finite Gap Sets

Maxim Zinchenko, *University of New Mexico, Albuquerque*

In this talk I will discuss recent progress on the asymptotics of Chebyshev polynomials on finite gap sets.

MS3: Inverse Problems and Imaging I

A Fast Accelerated Bundle Level Method for Large Scale Convex Optimization

Yunmei Chen, *University of Florida*

We present a fast accelerated prox-level (FAPL) method for large scale ball constrained and unconstrained convex optimization. It achieves optimal iteration complexity in theory, and reduces computation time and increases accuracy significantly in practice. This is accomplished by reducing the number of sub-problems involved in most existing bundle level type methods, and the novel algorithm to solve the sub-problem exactly. Our numerical results on solving large-scale least square problems and total variation based image reconstruction have shown great advantages of the FAPL methods over several state-of-the-art first-order methods.

TBA

Zuhair Nashed, *University of Central Florida*

TBA

Inverse Elastic Surface Scattering with Near-Field Data

Peijun Li, *Purdue University*

In this talk, we present a novel computational method for solving the inverse elastic surface scattering problem by using the near-field data. The method requires only a single illumination with one frequency and one incident angle. Numerical experiments will be shown that it is capable of reconstructing the scattering surfaces with subwavelength resolution.

Active Manipulation of Fields

Daniel Onofrei, *University of Houston*

In this talk we will present our new results regarding the near field active manipulation for acoustic and electromagnetic fields. In the first part of the talk we will discuss our results in the setting of the scalar Helmholtz equation. In this context, through a detailed sensitivity study, a qualitative comparison between existent far field schemes and the proposed near field scheme will be offered which will prove the feasibility of the latter approach. Then, in the second part of the talk we will present our theoretical approach for the active manipulation of electromagnetic fields in homogeneous isotropic linear media. Numerical results will be shown in the context of tuning normal modes in a cylindrical open waveguide.

MS4: Multiscale Modeling in Cancer: From Genotype to Phenotype I

Nonlinear Networks Dynamics and Opposite Effects of Wnt5a on Motility in Melanomas

Nidhal Bouaynaya[1], Mohammed Rasheed[2], and Hassan Fathallah Shaykh[3], *Rowan University*[1], *University of Arkansas*[2], *University of Alabama at Birmingham*[3]

Understanding how networks react to molecular targeting is important in biological sciences and medicine. Here, we encounter unusual nonlinear dynamics after targeting of Wnt5a, which enhances motility in 3/5 melanoma cell lines and represses motility in the other two. To explain this behavior we develop an optimization-driven general method for recovering networks from perturbation experiments. The models, consisting of ordinary differential equations representing signed directed graphs, are applied to a set of seven proteins that are key in classifying melanomas and in predicting biological phenotypes. To dampen the noise in biological data, we perform four replicates of each protein assay. Predictions from the computed networks were validated by motility experiments. The results uncover key principles of nonlinear molecular dynamics with wide implications in biological and medical sciences. Furthermore, the methodology and models are applicable to a wide range of biological networks.

Modeling of in Vivo Experiments of Metastatic Initiation and Tumor-Tumor Spatial Interactions

Etienne Baratchart, *INRIA Bordeaux, France*

Little is known about the detailed mechanisms of metastasis establishment in a distant organ, due to lack of experimental means to observe the process at this early stage. To resolve this further, we conducted a theoretical study based on data from an orthotopic murine experimental system of metastatic renal cell carcinoma. We first confronted our temporal data of total number of cells in the lungs with a mathematical model for the total metastatic burden dynamics. The results suggested as inadequate a naive theory of metastatic development where metastases would spread from the primary tumor and then grow independently from each other as well as from other parts of the system. Instead, we propose that metastatic germs growing from one or few cells could be aggregating, resulting in a similar total mass but a lower number of metastases. This led us to investigate the effect of tumor-tumor spatial interactions on the global metastatic burden dynamics. A novel mathematical model based on pressure-mediated growth was derived and shown able to fit the growth of metastatic lung nodules retrieved from magnetic resonance imaging (MRI) data. As a non trivial outcome from this analysis and under our modeling assumptions, the model predicted that total growth of two neighboring tumors was considerably impaired (31% 1.5% size reduction), as compared to the growth of two independent tumors. Our results provide a quantitative assessment of how much individual tumors growth is suppressed when tumors are in contact interactions. Moreover, they have implications for theories of metastatic development and suggest that global metastatic dynamics could emerge from the combined effects of fractionation of the total mass and spatial interactions between metastatic germs.

Data Assimilation in Lung Metastases Modeling: Towards Patient Calibrated Models Using Imaging Devices

Oliver Saut, *INRIA Bordeaux, France*

Data assimilation in lung metastases modeling: towards patient calibrated models using imaging devices Lung metastases are a therapeutical challenge as some as slowly evolving while others show an aggressive growth. This makes it difficult for clinicians to determine which nodule is to be treated first on patients where many are present. As this patients are often weak and old, they seek to avoid any unnecessary invasive intervention.

In collaboration with Institut Bergonié (Bordeaux, France), we have developed a spatial mathematical model for the growth of these nodules and a data assimilation technique to recover its patient specific parameters from a sequence of medical images. This talk will describe the different challenges that had to be overcome and some results on clinical cases.

Level Set Segmentation Using Non-Negative Matrix Factorization with Application to MRI

Dimah Dera[1], Nidhal Bouaynaya[1], and Hassan Fathallah Shaykh[2], *Rowan University*[1], *University of Alabama at Birmingham*[2]

We present a new deformable model for image segmentation based on the level set method (LSM) and probabilistic non-negative matrix factorization (PNMF). The proposed model characterizes the histogram of the image, calculated over the image blocks, as nonnegative combinations of basic histograms computed using the PNMF algorithm. These basic histograms form a clustering of the image. Our model also takes into account the intensity inhomogeneity or bias field of medical images. In a level set formulation, this clustering criterion defines an energy in terms of the level set functions that represent a partition of the image domain. The image segmentation is achieved by minimizing this energy with respect to the level set functions and the bias field. Our method is compared, using brain MRI, to two other state-of-the-art level set methods that are based on k-means clustering and local Gaussian distribution fitting. It is shown that the proposed PNMF LSM is less sensitive to model parameters, more robust to noise in the image and, at the same time, has a higher convergence rate. These advantages are due to the fact that the proposed approach i) relies on the histogram for local clustering rather than image intensities, and ii) does not introduce additional model parameters to be simultaneously estimated with the bias field and the level set functions.

MS5: Nonlinear PDEs of Conservation Laws and Fluid Mechanics I

Asymptotic Expansion of Hyperbolic Evolution Operators

Robin Young, *University of Massachusetts*

We describe perturbation results for hyperbolic evolution equations: if the data admits an expansion in powers of ϵ, then so does the solution. This problem is part of our long-standing program (with Blake Temple) to construct periodic solutions of Euler. By differentiating the evolution operator, we derive a Taylor expansion, valid before blowup of the solution. This method loses derivatives, so we study the exact linearization around an arbitrary solution via a Neumann series.

Periodic Solutions to Sign-Changing Liouville Equations

Ralph Saxton, *University of New Orleans*

We consider periodic solutions to an initial boundary value problem for a Liouville equation with sign-changing weight. A representation formula exists which admits classes of singular and nonsingular boundary data and predicts that solutions may blow up. In the case of singular boundary data we study the effects the induced singularity has on the interior regularity of solutions. Regularity criteria are also found for a generalized form of the equation. (Work with A. Sarria).

Some Recent Results for Hyperbolic Balance Laws

Yanni Zeng, *University of Alabama at Birmingham*

In this talk we discuss some recent results for a general system of hyperbolic balance laws. We consider the Cauchy problem near an equilibrium state. Under a set of assumptions, which include an entropy function and the Shizuta-Kawashima dissipation condition, we obtain the existence of global solution and large time behavior. We also discuss the consequence of the removal of the Shizuta-Kawashima condition, as happens in the dynamics of real gasses.

Wellposedness of Variational Wave Equation

Geng Chen, *Georgia Institute of Technology*

In this talk, we discuss the well-posedness of variational wave equations.

MS6: Numerical Approximation of Partial Differential Equations I

Schrödinger Equation with Fractional Laplacians

Yanzhi Zhang, *Missouri University of Science and Technology*

Recently, one debate in the literature is whether the fractional Schrödinger equation in an infinite potential well has the same eigenfunctions as those of its standard (non-fractional) counterpart. Due to the nonlocality of the fractional Laplacian, it is challenging to find the eigenvalues and eigenfunctions of the fractional Schrödinger equation analytically. In this talk, we numerically study the eigenfuctions of the fractional Schrödinger equation.

A Meshfree Implicit Filter for Solving Nonlinear Filtering Problems

Feng Bao, *Oak Ridge National Laboratory*

We consider a nonlinear filtering problem where a signal process is modeled by a stochastic differential equation and the observation is perturbed by a white noise. The goal of nonlinear filtering is to find the best estimation of the signal process based on the observation. An implicit Bayesian filter was proposed to improve the long term and stable computation of particle filter. In this presentation, we shall present an algorithm to improve the efficiency of the implicit filter through the use of meshfree approximations to the solutions of nonlinear filtering problems.

An Indirect Spectral Method for Fractional Differential Equations

Hong Wang, *University of South Carolina*

Fractional differential equations (FDEs) provide an adequate description of anomalously diffusive transport processes. Recent study shows that FDEs with smooth coefficients may generate solutions with strongly local behavior and poor regularity. Consequently, a traditional spectral method need not generate high-order accuracy for FDEs with smooth coefficients. We present an indirect spectral method for a variable-coefficient FDE, which has a proved high-order accuracy as long as the problem has smooth coefficients. Numerical results are presented to show the utility of the method.

The Numerical Approximation of a Generalized Bio-Convection Flow

Song Chen, *University of Wisconsin at La Crosse*

Bio-convection occurs due to on average upward swimming micro-organisms. We will consider a generalized convective flow modeling the stationary and evolutionary behavior of the phenomenon. In this model, the viscosity is assumed to be dependent on concentration of the micro-organisms. The well posedness of the problem will be studied using Rothe's method. The numerical approximation of the solution will then be conducted using finite element method. At last I will show the computational result and compare it to the real experiment.

MS7: Optimal Control, Optimization, Inverse Problems and Numerical Simulations with Applications I

Global Well-Posedness and Uniform Stability of a Nonlinear Thermo-Elastic PDE System

Xiang Wan, *University of Virginia*

We consider a nonlinear thermoelastic system defined on an open bounded set Ω with simply supported boundary conditions imposed on $\Gamma = \partial\Omega$. The background will be introduced first, followed by reviewing the work on the case $\gamma = 0$. Our challenge is to consider the case $\gamma > 0$. From a mathematical point of view the most important message is that the analyticity and maximal regularity of the associated linear system are gone. We will show the techniques to overcome this difficulty.

Optimal Control of a Parabolic PDE System Arising in Wound Healing

Stephen Guffey, *Western Kentucky University*

We consider a control problem for a system of four parabolic PDEs. The model described the behavior of oxygen, neutrophils, bacteria, and chemoattractant in a chronic wound, where the control represents the case of oxygen therapy. We wish to find the optimal level of supplemental oxygen to minimize both the bacteria count in the wound as well as the supplemental oxygen supplied. We discuss the existence of solutions for our system, the existence of an optimal control for our model, as well as the classification of the optimality system.

Constrained Optimization for Random Data Identification Problems

Catalin Trenchea, *University of Pittsburgh*

We present a scalable, parallel mechanism for stochastic identification/control for problems constrained by PDEs with random input data. Several identification objectives are discussed that either minimize the expectation of a tracking cost functional or minimize the difference of desired statistical quantities in the appropriate L^p norm. The stochastic parameter identification algorithm integrates an adjoint-based deterministic algorithm with the sparse grid stochastic collocation FEM approach. The proof of the error estimates uses a Fink-Rheinboldt theory.

Numerical Methods for Fractional Order Systems

Mehdi Vahab, *Florida State University*

Simulation of fractional order systems and controllers needs evaluation of fractional order operators. We will discuss the properties and applications of the Grünwald-Letnikov, Riemann-Liouville, Caputo and Riesz fractional derivatives. Numerical evaluations of these operators and numerical algorithms for their accurate calculations will be presented. We will show the effect of the order of fractional derivatives for different types of PDEs and show the results for these systems in which solution may develop discontinuities.

MS8: Recent Advances in Statistical Learning Theory

Functional Linear Regression Using Gaussian Kernel

Jun Fan, *University of Wisconsin-Madison*

Functional data analysis is a branch of data science that analyzes infinite dimensional data such as curves or images. In this talk, we will introduce a reproducing kernel Hilbert space approach to functional linear regression. The algorithm is generated from Tikhonov regularization scheme associated with Gaussian kernel. We show that the convergence rate for prediction risk is minimax-optimal up to a logarithmic factor, whatever the smoothness level of the slope function.

Analysis of Some Online Learning Algorithms with Kernels

Yiming Ying, *University at Albany, State University of New York*

Many machine learning tasks can be formulated as a regularization framework associated with a loss function and a regularization term in a reproducing kernel Hilbert space (RKHS). The main difficulty in obtaining optimal solutions of such formulations is the volume of the data, where there are many observations (large n). Online algorithms such as stochastic gradient descent which pass over the data only once, are widely used in practice. In this talk, I will give an overview of our theoretical contribution in this research direction. In particular, for standard pointwise learning problems I will present convergence results of online learning algorithms for both regularized and un-regularized formulations. For pairwise learning problems such as ranking and metric/kernel learning, I will describe our recently proposed algorithm called Opera and present its convergence rates.

A Refined Algorithm of Sliced Inverse Regression

Ning Zhang, *Middle Tennessee State University*

Sliced inverse regression is a statistical method for dimension reduction. We proposed a refined implementation by allowing overlapping slices. Simulation studies show that the refined algorithm is able to estimate the effective dimension reduction space more accurately and more stably.

MS9: Tensor Computations and Applications I

Symmetric Outer Product Decomposition for Tensors

Christina Glenn, *University of Alabama at Birmingham*

Tensor decomposition methods that decrease tensor complexity while lowering computational costs are in high demand. Symmetric Outer Product Decomposition (SOPD) factors a fully (partially) symmetric tensor into a number of rank-one symmetric tensors. Few numerical methods exist for finding the SOPD. The standard method, Alternating Least Squares (ALS), often yields wrong solutions. We propose a new iterative method for SOPD called Partial Column-wise Least Squares (PCLS). Numerical examples are provided to compare the performance of PCLS to ALS for the SOPD.

Tensors as Linear Operators: Implications for Multiway Data Analytics

Shuchin Aeron, *Tufts University*

In this talk we will consider several applications of a recently proposed algebraic framework, which considers multiway data or tensors as linear operators over free modules. Using this perspective in this talk we will focus on two problems for multiway data, namely data completion from missing entries, and unsupervised clustering of (2-D) images. For both of these problems we will derive probably optimal algorithms with performance guarantees that parallel recent results for one-dimensional data. We will also show the performance of the proposed methods on some real data sets and compare with some of the existing techniques. We will then discuss some implications of these results and directions of future work.

Low Rank Approximation of Tensor from the Viewpoint of Sparsity

Xiaofei Wang, *Northeast Normal University, China and University of Alabama at Birmingham*

The goal of this paper is to find a low rank approximation for a given tensor. Specifically, we also give a computable strategy on calculating the rank of a given tensor, basing on approximating the solution of the NP-hard problem: $\min_{\mathcal{B}} rank(\mathcal{B}) \quad s.t. \|\mathcal{A} - \mathcal{B}\|_F^2 \leq \varepsilon$ for a given tensor $\mathcal{A}$.

MS10: Variational Models and Their Fast Algorithms in Mathematical Imaging

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Alternating Direction Method of Multiplier for Elastica Denoising

Sung Ha Kang, *Georgia Institute of Technology*

Inspired by recent numerical developments, we propose a new version of alternating direction method of multiplier (ADMM) for Euler's Elastica base denoising model. The main contribution is to design a simple and fast method, which is also easy to choose parameters.

Fast Decentralized Gradient Descent Method

Xiaojing Ye, *Georgia State University*

We consider the decentralized consensus optimization problem on a connected network where each node privately holds a part of objective function and data. The goal is to find the minimizer for the whole objective function while each node can only communicate with its neighbors during computations. We present a fast decentralized gradient descent method whose convergence does not require diminishing step sizes as in regular decentralized gradient descent methods, and prove that this new method can reach optimal convergence rate of $O(1/k^2)$ where k is the communication/iteration number.

A Decoupled Unconditionally Stable Numerical Scheme for the Cahn-Hilliard-Hele-Shaw System

Daozhi Han, *Florida State University*

We propose a novel decoupled unconditionally stable numerical scheme for the simulation of two-phase flow in a Hele-Shaw cell which is governed by the Cahn-Hilliard-Hele-Shaw system with variable viscosity. The temporal discretization of the Cahn-Hilliard equation is based on a convex-splitting of the associated energy functional. Moreover, the capillary forcing term in the Darcy equation is separated from the pressure gradient at the time discrete level by using an operator-splitting strategy. Thus the computation of the nonlinear Cahn-Hilliard equation is completely decoupled from the update of pressure. Finally, a pressure-stabilization technique is used in the update of pressure so that at each time step one only needs to solve a Poisson equation with constant coefficient. We show that the scheme is unconditionally stable. Numerical results are presented to demonstrate the accuracy and efficiency of our scheme.

A Variational Model for Shape from Shading

Wei Zhu, *University of Alabama, Tuscaloosa*

Shape from shading (SFS) is a classic and fundamental problem in image processing. It aims to reconstruct the 3D shape of a surface from a given 2D irradiance image, which is a highly ill-posed problem. In this talk, we will address a novel variational model that employs mean curvature of image surface for the SFS problem. We will also discuss some features of this model and the fast algorithm using augmented Lagrangian methods.

MS11: Accurate and Efficient Time Integration Methods for Unsteady PDEs II

Further Study of Back and Forth Error Compensation and Correction Method for Advection and Hamilton-Jacobi Equations

Yingjie Liu, *Georgia Institute of Technology*

We further study the properties of the back and forth error compensation and correction (BFECC) method for advection equations such as those related to the level set method and for solving Hamilton-Jacobi equations on unstructured meshes. In particular, we develop a new limiting strategy. This new technique is very simple to implement even for unstructured meshes and is able to eliminate artifacts induced by jump discontinuities in derivatives of the solution as well as by jump discontinuities in the solution itself (even if the solution has large gradients in the vicinities of a jump). Typically, a formal second order method method for solving a time dependent Hamilton-Jacobi equation requires quadratic interpolation in space. A BFECC method on the other hand only requires linear interpolation in each step, thus is local and easy to implement even for unstructured meshes. Joint with Lili Hu and Yao Li.

A High Order Time Splitting Method Based on Integral Deferred Correction for Semi-Lagrangian Vlasov Simulations

Wei Guo, *Michigan State University*

The dimensional splitting semi-Lagrangian methods with different reconstruction/interpolation strategies have been applied to kinetic simulations in various settings. However, the temporal error is dominated by the splitting error. In order to have numerical algorithms that are high order in both space and time, we propose to use the integral deferred correction (IDC) framework to reduce the splitting error. The proposed algorithm is applied to the Vlasov-Poisson system, the guiding center model, and incompressible flows.

Long-Time Numerical Integration of the Generalized Nonlinear Schrödinger Equation with Time Steps Exceeding the Instability Threshold

Taras Lakoba, *University of Vermont*

In applications focusing on obtaining statistics of solutions, relatively low accuracy (0.1%) is acceptable. Then one can use larger time steps to reduce simulation time, but larger steps may cause numerical instability (NI). We consider two methods of suppressing NI. One method works for equations with bounded/localized "potential" and consists of simply applying absorbing boundary conditions. The alternative is to use a leap-frog-type exponential time differencing method instead of the split-step method.

Compact Implicit Integration Factor Method for a Class of High Order Differential Equations

Xinfeng Liu, *University of South Carolina*

When developing efficient numerical methods for solving parabolic types of equations, severe temporal stability constraints on the time step are often required due to the high-order spatial derivatives and/or stiff reactions. The implicit integration factor (IIF) method, which treats spatial derivative terms explicitly and reaction terms implicitly, can provide excellent stability properties in time with nice accuracy. One major challenge for the IIF is the storage and calculation of the dense exponentials of the sparse discretization matrices resulted from the linear differential operators. The compact representation of the IIF (cIIF) can overcome this shortcoming and greatly save computational cost and storage. In this talk, by treating the discretization matrices in diagonalized forms, we will present an efficient cIIF method for solving a family of semilinear fourth-order parabolic equations, in which the bi-Laplace operator is explicitly handled and the computational cost and storage remain the same as to the classic cIIF for second-order problems. In particular, the proposed method can deal with not only stiff nonlinear reaction terms but also various types of homogeneous or inhomogeneous boundary conditions.

MS12: Inverse Problems II

The Inverse Oilfield Problem

Ian Knowles, *University of Alabama at Birmingham*

Secondary oil recovery involves pumping fluids into injection wells to force oil towards the production wells. Effective recovery strategies require a knowledge of subsurface properties, such as permeability, throughout the oilfield. We introduce a new variational method for the determination of subsurface parameters from well data. This is joint work with my UAB graduate student Fatin Alawam.

Global Uniqueness and Stability of an Inverse Problem for the Schrödinger Equation on a Riemannian Manifold via One Localized Boundary Measurement

Roberto Triggiani, *University of Memphis*

We consider a mixed problem for the Schrodinger equation on a nite dimen- sional Riemannian manifold with magnetic and electric potential coecients. the goal is a nonlinear problem of the recovery of the electric potential coecient by means of only one boundary measurement on an explicitly identied portion of the boundary and over an arbitrarily short time interval.We obtain global uniqueness of the recovery and Lipschitz stability of the recovery. Two key ingredients: Car- leman estimates and optimal interior and boundary regularity. Joint work with Zhifei Zhang

Control and Inverse Problems for a String

Sergey Avdonin, *University of Alaska, Fairbanks*

We consider boundary control and inverse problems for a nonhomogeneous string with masses attached at interior points. We prove exact controllability of the string in a sharp time interval with respect to a Sobolev space with the regularity exponent increasing at each 'mass' point. We demonstrate that the density of the string, masses and their coordinates can be recovered using the dynamical Dirichlet-to-Neumann map associated with a boundary point of the string.

MS13: Inverse Problems and Imaging II

Illusory Shapes via Corner Fusion

Sung Ha Kang, *Georgia Institute of Technology*

We propose a method for constructing illusory shapes from convex corners. Corner bases are fused together by elastica energy to construct both foreground illusory shapes and background occluded shapes. Robust numerical schemes are developed, and several generic examples are presented.

A Fast Algorithm for Super-Resolution of Spectrally Sparse Signals

Jianfeng Cai, *University of Iowa*

We propose a fast algorithm to reconstruct a spectrally sparse signal from a small number of randomly observed time domain samples. Different from conventional compressed sensing where frequencies are discretized, we consider the super-resolution case where the frequencies can be any values in the normalized continuous frequency domain [0,1]. Our signal recovery problem can be converted into a low rank Hankel matrix completion problem, for which we propose an efficient feasible point algorithm named projected gradient algorithm(PGA). We give the convergence analysis of the algorithm. The algorithm can be further accelerated by the FISTA-like technique. Numerical experiments are provided to illustrate the effectiveness of our proposed algorithm.

Mathematical Modeling and Methods of Signal Separations

Yuanchang Sun, *Florida International University*

In this talk, the speaker shall consider three classes of signal separation problems depending on the available knowledge of the source signals (minimal, partial or full knowledge of a template of source signals). The problems are blind, partially blind and template assisted signal separation. Deterministic and statistic models and their numerical methods will be formulated . Numerical results on real world including NMR, DOAS, and Raman spectroscopy will be presented.

Numerical Methods for Hyperelastic Image Registration

Lars Ruthotto, *Emory University*

Image registration aims at finding geometrical correspondences between two or more images. Image registration is commonly phrased as a variational problem that is known to be ill-posed and thus regularization is of key importance.

This talk presents applications of and fast numerical methods for regularization functionals based on the theory of hyperelastic materials. These methods guarantee existence of solutions to the variational problem and ensure the invertibility of the computed transformation between the images.

MS14: Multiscale Problems and Methods in Numerical Simulations

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Multi-Scale Data Assimilation for Turbulent Systems

Yoonsang Lee, *New York University*

Data assimilation of turbulent signals is an important challenging problem because of the extremely complicated large dimension of the signals and incomplete partial noisy observation. We propose a suite of multi-scale data assimilation methods which use conditional Gaussians. The methods are tested on a six dimensional conceptual dynamical model for turbulence which mimics interesting features of anisotropic turbulence including two way coupling between the large and small scale parts, intermittencies, and extreme events.

A Methods for Multiscale Inverse Problems

Christina Frederick, *Georgia Institute of Technology*

I will discuss inverse problems involving elliptic partial differential equations with highly oscillating coefficients. The multiscale nature of such problems poses a challenge in both the mathematical formulation and the numerical modeling, which is hard even for forward computations. I will discuss uniqueness of the inverse in certain problem classes and show numerical model examples that can be applied to inverse problems in medical imaging and exploration seismology.

An Iterative Substructuring Method for Problems Posed in H(div)

Duk-soon Oh, *Rutgers University*

A BDDC(balancing domain decomposition method by constraints) algorithm, an iterative substructuring method, is defined by primal constraints, a weighted average across the interface between the subdomains, and local components given in terms of Schur complements of local subproblems. A BDDC for vector field problems discretized with Raviart-Thomas elements is introduced. Our method is based on a new type of weighted average and adaptive coarse space method to deal with highly varying coefficients.

A Multiscale Computation for Highly Oscillatory Dynamical Systems Using an EMD-Type Method

Seong Jun Kim, *Georgia Institute of Technology*

The heterogeneous multiscale method (HMM) is devised to compute the coarse scale behavior in a multiscale system without fully resolving the fine scale solutions. Using multi-grid type of coupling, at each coarse time step, the solver acquires the necessary information by resolving fine scale models. The Adaptive Local Iterative Filtering (ALIF) is a nonlinear signal analysis strategy which decomposes a signal into several intrinsic mode functions and extracts essential information. In this talk, I will propose a numerical method that combines HMM and ALIF to compute the slow dynamics for highly oscillatory dynamical systems.

MS15: Multiscale Modeling in Cancer: From Genotype to Phenotype II

Effects of Anti-Angiogenesis on Glioblastoma Growth and Migration: Model to Clinical Predictions

Elizabeth Scribner[1], Olivier Saut[2], Thierry Colin[2], and Hassan Fathallah Shaykh[1], *University of Alabama at Birmingham*[1], *Bordeaux INP and INRIA, France*[2]

Glioblastoma multiforme (GBM) causes significant neurological morbidity and short survival times. Brain invasion by GBM is associated with poor prognosis. Recent clinical trials of bevacizumab in newly-diagnosed GBM found no beneficial effects on overall survival times; however, the baseline health-related quality of life and performance status were maintained longer in the bevacizumab group and the glucocorticoid requirement was lower. Here, we construct a clinical-scale model of GBM whose predictions uncover a new pattern of recurrence in 11/70 bevacizumab-treated patients. The findings support an exception to the Folkman hypothesis: GBM grows in the absence of angiogenesis by a cycle of proliferation and brain invasion that expands necrosis. Furthermore, necrosis is positively correlated with brain invasion in 26 newly-diagnosed GBM. The unintuitive results explain the unusual clinical effects of bevacizumab and suggest new hypotheses on the dynamic clinical effects of migration by active transport, a mechanism of hypoxia-driven brain invasion.

Mechanisms of Glioma Formation: Exploring Glioma Growth Through Dialectic Biological-Computational Approaches

Pedro R. Lowenstein[1], Gregory J. Baker[1], Sebastien Motsch[2], and Maria G. Castro[1], *The University of Michigan*[1], *Arizona State University*[2]

In malignant brain tumors invasive glioma cells become associated with several brain compartments: blood vessels, white matter fibers, brain parenchyma, and meninges. How individual microanatomical patterns of invasion lead to eventually deadly tumor growth, and influence disease progression and clinical outcomes remain poorly understood. We have investigated how early perivascular growth of brain tumor cells affects larger patterns of glioma growth and the formation of macroscopic tumors. As glioma cells migrate on brain vessels within the highly vascularized brain, we conclude that in these cases the formation of macroscopic tumors can be explained by the exclusive growth of glioma cells on brain vessels; thus, we also studied tumor growth in response to anti-angiogenic therapy. Orthotopically implanted rodent and human glioma stem cells invaded the brain and proliferated within the potential brain perivascular space. This form of brain tumor growth and invasion also characterized endogenous mouse brain tumors, primary human glioblastoma, and peripheral cancer metastasis to the human brain. Perivascularly invading brain tumors become vascularized by pre-existing microvessels as individual gliomas cells use the potential perivascular space as a pathway for tumor invasion. Agent-based computational modeling recapitulated biological perivascular glioma growth without the need to specifically account for parameters modeling neoangiogenesis. As predicted by the computational model, the requirement for neoangiogenesis in our various glioma models was tested by treating animals with angiogenesis inhibitors bevacizumab and DC101. These inhibitors induced the expected vessel normalization, but failed to reduce tumor growth or improve survival of mice bearing orthotopic or endogenous gliomas; this treatment was also shown to preserve the structure of brain vessels and exacerbate brain tumor invasion. We are also examining the progression of cell division in relation to the different compartments occupied by tumor cells to test the "growth or grow" hypothesis of tumor growth. Our results provide compelling experimental evidence supporting a mechanism of macroscopic glioma formation that relies on the iterative invasion of blood vessels and consequent filling in of brain matter situated between any two blood vessels. In addition, our data also indicate a potential pathway to explain the recently described failure of clinically used antiangiogenics to extend the survival of human glioma patients.

Modeling of the Resistance to Treatments for Gastro-Intestinal Stromal Tumors

Thierry Colin, *Bordeaux INP and INRIA, France*

Gastro-intestinal stromal tumor can create lesions to the liver in the metastatic phase. The evolution of the disease is usually followed using CT-scans and targetted therapies (anti-angiogenic drugs and tyrosin kinase inhibitors) are used to control the growth. These treatment have most of the time a good efficiency but unfortunately at sometime a relapse occurs. Based on an accurate analysis of medical images, we provide a patient-dependent model that reproduces qualitatively and quantitatively the spatial tumor evolution, as followed up by the clinical data. In particular, specific aspects of tumor growth as spatial heterogeneity and treatment failures can be explained by our model. We will present the construction of the model as well as some well-posedness results.

Motility Determines Growth, Recurrence, and Treatment Response: Insights From a Mathematical Model of GBM

Hassan Fathalla-Shaykh[1], Elizabeth Scribner[1], Olivier Saut[2], and Thierry Colin[2], *University of Alabama at Birmingham*[1], *Bordeaux INP and INRIA France*[2]

Glioblastoma multiforme (GBM) is a malignant brain tumor with poor prognosis and inherent propensity to invade the brain. We apply a concise system of partial differential equations that models GBM biology at the scale of magnetic resonance imaging, to replicate the patterns of recurrence of GBM treated by anti-angiogenesis. The findings reveal that tumor motility determines tumor growth and recurrence and uncover a novel principle linking the mechanisms of brain invasion to tumor biology.

MS16: Nonlinear PDEs of Conservation Laws and Fluid Mechanics II

Shock Formations for 3-Dimensional Wave Equations

Shuang Miao, *University of Michigan*

In this talk I will present a geometric perspective on shock formations for a class of quasilinear wave equations which admit global smooth solutions with small data. We exhibit a family of smooth initial data leading to breakdown of smoothness of the solution. The work combines the ideas from fluid mechanics e.g. shock formation for Euler equations and from general relativity e.g. formation of trapped surfaces. This is a joint work with Pin Yu.

Global Solutions to the Gas-Vacuum Interface Problem with Physical Singularity of Compressible Euler Equations with Damping

Huihui Zeng, *Tsinghua University and Harvard University*

I will present some recent results on the global solutions to the gas-vacuum interface problem of compressible Euler equations with physical singularity of the sound speed being $C^{1/2}$-Hölder continuous near vacuum boundaries. For this problem, the global existence and convergence to the Barenblatt self-similar solution of the induced porous media equation as time goes to infinity is proved, with detailed convergence rate. The long time asymptotics of the gas-vacuum interfaces are also given.

On Rotating Star Solutions to the Euler-Poisson Equations – Inner Hard Core and Non-Isentropy

Yilun Wu, *Indiana University*

The Euler-Poisson equations are used in astrophysics to model the motion of gaseous stars. Auchmuty and Beals in 1971 found a family of rotating star solutions by solving a variational free boundary problem. Recent interests in the astrophysics community suggest one to extend the picture to include a solid core together with its gravitational fields. In this talk, we will discuss several results in this direction. Furthermore, we will explore the effects of non-isentropic equation of state.

Global Dynamics of a System of Hyperbolic Balance Laws Arising from Reinforced Random Walk

Kun Zhao, *Tulane University*

In this talk, the global dynamics of large-amplitude classical solutions to a system of hyperbolic balance laws arising from reinforced random walk will be presented. In particular, the results rigorously demonstrate the phenomenon of "collapse" (convergence to uniform equilibrium states) in repulsive (negative) chemotactic movement.

Global Regularity and Long Time Dynamics for a Vacuum Free Boundary Problem of Viscous Gaseous Stars

Tao Luo, *Georgetown University*

In this talk, I will present some recent results joint with Zhouping Xin and Huihui Zeng on the global regularity and long time dynamics, in particular, the long time dynamics of the vacuum boundary, of solutions to a vacuum free boundary problem of viscous gaseous stars.

MS17: Numerical Approximation of Partial Differential Equations II

Darcy Fluid Flow with Deposition

Javier Ruiz-Ramirez, *Clemson University*

In this talk we consider a Darcy flow problem coupled with a deposition function. Our model arises in the context of filtration, where a fluid carrying some particulate flows through some porous medium. As the particulate deposits, the porosity of the filter changes, modifying the flow conditions. In the talk we will motivate the model, discuss the existence and uniquess of our problem, provide an a priori error analysis and show some computational results.

A Multi-Domain Spectral IPDG Method for the Helmholtz Equation

Lunji Song, *Lanzhou University*

We present a multi-domain spectral method, based on an interior penalty discontinuous Galerkin (IPDG) formulation, for the exterior Helmholtz problem truncated via an exact circular Dirichlet-to-Neumann (DtN) boundary condition. An effective iterative approach is proposed to localize the global DtN boundary condition and is given in three specific cases. Under a discontinuous Galerkin formulation, the proposed method allows to derive explicit wave number dependence estimates of the spectral scheme.

Multilevel Sampling with Adaptive Mesh Refinement

Hans-Werner van Wyk, *Florida State University*

Adaptive mesh refinement has become an invaluable tool in numerical simulations of systems governed by partial differential equations (PDEs), leading to considerable reductions in computational work. For PDEs with stochastic parameters, however, spatial adaptivity is complicated by the presence of multiple realizations, each with potentially different local error estimates. This talk discusses how adaptive mesh refinement can be naturally incorporated into the framework of multilevel sampling methods. Numerical illustrations accompany our theoretical results throughout.

Error Estimation for Quasi-Newtonian Fluid-Structure Interaction Problems

Shuhan Xu, *Clemson University*

We consider a monolithic scheme for fluid-structure interaction problems involving an incompressible quasi-Newtonian fluid. The monolithic formulation is obtained based on the Arbitrary Lagrangian Eulerian method (ALE) with the matching conditions at the interface. The stability and error analysis are performed for the finite element approximation and fully discretized scheme. Some numerical experiments that confirm the theoretical analysis are presented.

MS18: Optimal Control, Optimization, Inverse Problems and Numerical Simulations with Applications II

Curved Meshing for High Reynolds Flows Solved Using High Order Framework

Cécile Dobrzynski, *Institut Polytechnic of Bordeaux*

When high order schemes are used for compressible simulations, the subparametric discretization used for geometry's representation (usually piecewise-linear) may lead to errors dominating errors related to the variable field discretization. To solve this problem, we need to generate curved meshes with the same order of the numerical schemes. That means curved elements are compulsory for approximations of order more than three.

Our strategy to generate simplicial curved mesh is the following: we consider the initial straight mesh as a deformable elastic solid and we impose a displacement on its boundaries to obtain a curved mesh representing the curved geometry. The validity of the curved volumic mesh is obtain thanks to linear elasticity equation and some properties of Bezier curves/surfaces.

Several examples are performed in 2d and 3D, in particular for several turbulent simulations such a M6 wing, a RAE 2827 airfoil and a 2D wing-flap configuration.

Two Discontinuous Galerkin Spectral Element Cut-Cell Methods for the Stefan Problem

Chaoxu Pei, *Florida State University*

The Stefan problem is a moving boundary problem used to model phase change. A key issue is that the boundary domain is not known in advance, which requires one to compute the unknown domain as a part of the solution. We present two discontinuous Galerkin spectral element cut-cell methods for the Stefan problem. One uses the transformation technique. The other one involves extrapolation. Both methods can be shown to be spectrally accurate in space.

Uniform Stabilization to a Nontrivial Equilibria of a Fluid Structure Interaction Model

Yongjin Lu, *Virginia State University*

We consider uniform stability to a nontrivial equilibrium of a nonlinear fluid structure interaction (FSI) defined on a two or three dimensional bounded domain. Stabilization is achieved via boundary and/or interior feedback controls implemented on both the fluid and the structure. The main technical difficulty is the mismatch of regularity of hyperbolic and parabolic component of the coupled system. This is overcome by considering special multipliers constructed from Stokes solvers. The uniform stabilization result reported here is global for the fully coupled FSI model.

MS19: Tensor Computations and Applications II

Equations for the Fifth Secant Variety of Segre Products of Projective Spaces

Luke Oeding, *Auburn University*

We describe a computational proof that the fifth secant variety of the Segre product of five copies of the projective line is a codimension 2 complete intersection of equations of degree 6 and 16. Our computations rely on pseudo-randomness, and numerical accuracy, so parts of our proof are only valid "with high probability". This is joint work with Steven Sam (UC Berkeley).

Eigenvectors of Non-Hermitian Random Matrices

Shannon Starr, *University of Alabama at Birmingham*

Largest and smallest singular values of non-Hermitian random matrices are important quantities for studying compressed sensing. Here we consider eigenvectors instead of singular values. There are many open questions.

Compressed Sensing in a Multilinear Sparse System of Genomic Interactions

Alexandra Fry, *University of Alabama at Birmingham*

The application of multilinear systems and compressed sensing on a biological model of viral replication will be discussed. This problem is motivated by the mathematical study of interactions among genes in cells. We show that a tensor restricted isometry property (TRIP) is necessary to find the unique sparse solution in the multilinear system. This solution can aid in drastically reducing the number of experiments needed to assess combinations of genes are necessary for viral replication.

Random Projections for Low Multilinear Rank Tensors

Carmeliza Navasca, *University of Alabama at Birmingham*

We proposed two randomized tensor algorithms for reducing multilinear ranks in the Tucker format. The basis of these randomized algorithms is from the randomized SVD of Halko, Martinsson and Tropp. Here we provide randomized versions of the higher order SVD and higher order orthogonal iteration. Moreover, we provide a sharper probabilistic error bounds for the matrix low rank approximation. Thus, we can provide theoretical error bounds for the tensor case. In addition, these randomized algorithms are implemented on an MRI dataset.

MS20: Accurate and Efficient Time Integration Methods for Unsteady PDEs III

Some Energy Stable Schemes for Phase Field Model With Moving Contact Lines

Xiaofeng Yang, *University of South Carolina*

We present some efficient energy stable schemes to solve a phase field model incorporating moving contact line. The model is a coupled system that consists of incom- pressible NavierStokes equations with a generalized Navier boundary condition and Cahn Hilliard equation in conserved form. By some subtle explicit-implicit treatments, we obtain a linear coupled energy stable scheme for systems with dynamic contact line conditions and a linear decoupled energy stable scheme for systems with static contact line conditions. The energy stability is obtained by rigorous proof and numerical results also show that the proposed schemes are very efficient and accurate.

Split-Step Method for Nonlinear Schrődinger Equations

Yanzhi Zhang, *Missouri University of Science and Technology*

Split-step methods have been widely used in solving time-dependent PDEs. In this talk, we discuss the numerical stability of the split-step method for solving the (fractional) nonlinear Schrodinger (NLS) equation. The stable conditions are analyzed for the plane wave solutions, and numerical experiments are provided to verify our analytical results. In addition, the performance of the split-step method is studied and compared in solving the standard and fractional NLS.

Discontinuous Galerkin Methods for the Shallow Water Equations with ADER-DT Time Stepping

Yulong Xing, *University of Tennessee*

Shallow water equations with a non-flat bottom topography have been widely used to model flows in rivers and coastal areas. In this presentation, we will talk about high-order discontinuous Galerkin methods with ADER-DT temporal discretizations for this system. We will show that the proposed methods are well-balanced and preserve the still water steady state exactly. Local time stepping of the ADER methods will also be studied to allows elements of different sizes to use different time steps. Some numerical tests are performed to verify the well-balanced property, high-order accuracy, and good resolution for general solutions.

Fast Operator Splitting Algorithms for Biomolecular Solvation Analysis

Shan Zhao, *University of Alabama, Tuscaloosa*

Recently, we have developed several operator splitting methods to efficiently and stably solve the nonlinear Poisson-Boltzmann (PB) equation for the electrostatics analysis of solvated biomolecules. The operator splitting framework enables an analytical integration of the nonlinear term that suppresses the instability. Both fully implicit alternating direction implicit (ADI) schemes and unconditionally stable locally one-dimensional (LOD) schemes are constructed, which provide fast PB solvers in electrostatic free energy analysis.

MS21: Inverse Problems III

Spectral Theory for Sturm-Liouville Operators With Distributional Potentials

Roger Nichols, *University of Tennessee at Chattanooga*

We discuss inverse spectral theory for singular differential operators on the interval (a, b) associated with rather general differential expressions of the type $Hf = r^{-1}[-(p[f' + sf])' + sp[f' + sf] + qf]$, where the coefficients are Lebesgue measurable on (a, b) with p^{-1}, q, r, s locally integrable on (a, b) and real-valued with p nonvanishing and r positive a.e. on (a, b). In particular, we explicitly permit certain distributional potential coefficients.

Carleman Formulas and Inverse Problems

Alexander Bukhgeym, *Wichita State University*

We focus on the relationship between the Carleman formula and the reconstruction of the two-dimensional refractive index in the Helmholtz equation.

Solving the Camassa-Holm Equation by Inverse Scattering

Rudi Weikard, *University of Alabama at Birmingham*

The Camassa-Holm equation is an integrable system with an associated Lax pair. Therefore it is possible to solve it by an inverse scattering transform. However, the scattering problem is for the left-definite equation $-y'' + 1/4y = \lambda wy$ where w may be of varying sign. The emphasis of the talk lies on the corresponding scattering and inverse scattering problem.

This is joint work with Malcolm Brown and Christer Bennewitz.

MS22: Nonlinear Differential Equations

Ill-Posedness of Some Water Wave Models

Jerry L. Bona, *University of Illinois at Chicago*

We discuss recent work revealing that certain naturally derived surface water wave models are not well posed in smooth function classes.

Initial-Boundary Value Problem for the BBM-Equation

Hongqiu Chen, *University of Memphis*

The so-called wave-maker problem for the BBM-equation is studied on the half-line. Improving on earlier results, global well-posedness is established for square-integrable initial data and boundary data that is only assumed to be locally bounded. Moreover, the method shows how the singular point propagates.

Local Discontnuous Galerkin Methods for the Korteweg-de Vries Equation

Ohannes Karakashian, *University of Tennessee*

The Local Discontinuous Galerkin (LDG) method for time dependent problems consists in treating numerically each spatial derivative as a separate variable by writing the equation in system form. We construct and analyze LDG discretizations for the Korteweg-de Vries equation. One difficulty faced by LDG methods is the need to generate approximations to the initial data, now a sequence of derivatives at t=0, which are optimal approximations and but must also satisfy certain compatibility conditions. We provide a general approach for the construction of optimal and compatible initial approximations.

Global Asymptotic Stability in a Model of Biological Networks

Hassan Fathallah-Shaykh, *University of Alabama at Birmingham*

Global asymptotic stability is of importance from a theoretical as well as an application point of view in several elds. We study a system of cubic polynomials that models biological networks. We show that the property that the interconnection matrix is Lyapunov diagonally stable is a key feature that determines convergence to a single equilibrium. We will give examples.

MS23: Nonlinear PDEs of Conservation Laws and Fluid Mechanics III

Non-Strictly Hyperbolic Systems, Singularities and Bifurcation

Katarzyna Saxton, *Loyola University*

We examine a 2x2 genuinely nonlinear hyperbolic system in (e, p) variables which loses the property of strict hyperbolicity wherever $e = 0$. In hyperbolically degenerate cases this may occur on sets $x =$ constant, along which singularities can form, even in the presence of damping in the system. Furthermore, these sets may bifurcate at some time to create secondary curves prior to blow up. We discuss the existence and properties of these additional curves. Numerical examples are considered for Riemann and smooth data.

Further Results on Irregular Weak Reflection

Allen Tesdall, *CUNY Staten Island*

Recent numerical solutions and shock tube experiments have shown the existence of a complex reflection pattern known as GMR which provides a resolution of the triple point paradox. This pattern is characterized by a discontinuous transition from supersonic to subsonic flow at the rear of each patch in a sequence of tiny supersonic patches. We study numerically the possibility of an alternate structure in which the transition from supersonic to subsonic flow is smooth.

On the Properties of Weak Solutions Describing Dynamic Cavitation in Nonlinear Elasticity

Alexey Miroshnikov, *University of Massachusetts*

In this work we study the problem of dynamic cavity formation in isotropic compressible nonlinear elastic media. Cavitating solutions were introduced by J.M. Ball [1982, Phil. Trans. R. Soc. Lond. A] in elastostatics and by K.A. Pericak-Spector and S. Spector [1988, Arch. Rational Mech. Anal.] in elastodynamics. They turn out to decrease the total mechanical energy and provide a striking example of non-uniqueness of entropy weak solutions (in the sense of hyperbolic conservation laws) for polyconvex energies. In our work we established various further properties of cavitating solutions. For the equations of radial elasticity we construct self-similar weak solutions that describe a cavity emanating from a state of uniform deformation. For dimensions d = 2,3 we show that cavity formation is necessarily associated with a unique precursor shock. We also study the bifurcation diagram and do a detailed analysis of the singular asymptotics associated to cavity initiation as a function of the cavity speed of the self-similar profiles. We show that for stress-free cavities the critical stretching associated with dynamically cavitating solutions coincides with the critical stretching in the bifurcation diagram of equilibrium elasticity.

Spectral and Nonlinear Stability of Viscous Detonation Waves

Greg Lyng, *University of Wyoming*

In this talk, we outline a program, combining analytical and numerical Evans-function techniques, for evaluating the spectral and nonlinear stability of viscous detonation waves. In the relatively simple case of Majda's qualitative combustion model, this program has been completely carried out, and we describe how to obtain nonlinear stability results for both strong (Lax-type) and weak (under compressive) detonation waves. Finally, we discuss the extension of this program to the physically relevant case of the Navier-Stokes equations modeling a compressible mixture of reacting gases. The results in this case are interesting.

MS24: Numerical Approximation of Partial Differential Equations III

Time Domain Decomposition Methods for Forward-and-Backward PDEs

Zhu Wang, *University of South Carolina*

The forward-and-backward partial differential equation system always appears in the optimal control and optimization problems. It is appealing to solve such a system directly since a single solve suffices to determine the optimal states, adjoint states, and controls. However, this approach is computationally expensive. In this talk, we present several time domain decomposition methods, which are based on a decomposition of the time domain into smaller subdomains, and are suited for implementation on parallel computer architectures. The effectiveness of these algorithms are verified by numerical tests.

ANALYSIS OF QUASI-OPTIMAL POLYNOMIAL APPROXIMATIONS FOR PARAMETERIZED PDES WITH DETERMINISTIC AND STOCHASTIC COEFFICIENTS

Hoang Tran, *Oak Ridge National Laboratory*

We present a generalized methodology for analyzing the convergence of quasi-optimal Taylor and Legendre approximations, applicable to a wide class of parameterized elliptic PDEs with both deterministic and stochastic inputs. Such approximations construct an index set that corresponds to the "best M-terms" based on sharp estimates of the polynomial coefficients. Several types of isotropic and anisotropic (weighted) multi-index sets are explored and computational evidence shows the advantage of our methodology compared to previously developed estimates.

Recent Developments of Fast Methods for FPDEs

Jinhong Jia, *Shandong University*

Because of the nonlocal property of fractional differential operators, the numerical methods for FPDEs often generate dense coefficient matrices, which often requires computational work of $O(N^3)$ to invert per time step and memory of $O(N^2)$. Furthermore, fractional differential equations with smooth coefficients may generate solutions with strongly local behavior. We report our recent work on fast methods for FPDEs on local grid refinement.

A Fast Numerical Method for Nonlocal Models

Su Yang, *University of South Carolina*

The direct solvers for nonlocal models require $O(N3)$ computational complexity and $O(N2)$ memory for a N-size problem.This imposes significant computational and memory challenge in realistic applications. We present a fast numerical method for nonlocal models by exploiting the structure of the stiffness matrix. This method reduces the memory to optimal order and computational complexity to almost optimal order. The significant computational and memory reduction of the fast method is better reflected in numerical experiments

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MS25: Optimal Control, Optimization, Inverse Problems and Numerical Simulations with Applications III

Analysis and Numerics for an Age- and Sex-Structured Population Model

Michael Pokojovy, *University of Konstanz, Germany*

In the present talk, we discuss a linear model of McKendrick-von Foerster-Keyfitz type for the temporal development of the age structure of a two-sex human population. For the underlying system of partial integro-differential equations, we exploit the semigroup theory to show the classical well-posedness and asymptotic stability in a Hilbert space framework under appropriate conditions on the age-specific mortality and fertility moduli. Finally, we propose an implicit finite difference scheme to numerically solve this problem and prove its convergence under minimal regularity assumptions. A real data application is also given.

Lotka-Volterra/Gompertz Competition Model for Tumor Growth

Philippe Laval, *Kennesaw State University*

We modify the Lotka-Volterra competition model by replacing the logistic growth part of one of the species by a Gompertz growth. We then analyze this new model, look at numerical solutions and also estimate the parameters of the model from existing data (inverse problem). An application of this work is in cancer models which use Lotka-Volterra. It has been noted that Gompertz growth was a better fit to describe the growth of tumors than logistic growth.

Parameter Estimation Techniques Applied to Stochastic Models

Thomas Robacker, *East Tennessee State University*

There are natural phenomena which are genuinely stochastic, for example, the spread of a disease where the deterministic system is not the most appropriate model and instead a stochastic model should be implemented. Parameter estimation techniques have been successfully and extensively applied to deterministic models based on ordinary differential equations but are in early development for stochastic models. Well established techniques for parameter estimation for deterministic systems are applied to two stochastic biological models - the Lokta-Volterra predator-prey and SIS epidemic models. We compare and contrast the different approaches and their effectiveness for these two simple models.

Mathematical Modeling of 2014 Ebola Virus Outbreak

Ana-Maria Croicu, *Kennesaw State University*

The last Ebola Virus Outbreak started in February 2014 in Guinea, West Africa, and spread into Liberia in March, Sierra Leone in May, and Nigeria in July 2014. According to WHO's website, as of 31 August 2014, 3685 cases and 1841 deaths have been reported. Due to high Ebola case fatality rate, the analysis of Ebola virus disease is critical to outbreak responses. S-E-I-R and S-I-R mathematical models are used to simulate the 2014 Ebola outbreak in West Africa.

CS1: Contributed Session I

The Discrete Agglomeration Model: The Moment Problem for the Autonomous Quadratic Kernel

James L. Moseley, *West Virginia University*

Agglomeration of particles in a fluid environment is an integral part of many industrial processes and has been the subject of scientific investigation. One model of the fundamental mathematical problem of determining the number of particles of each particle-size as a function of time for a system of particles that may agglutinate during two particle collisions uses the coagulation or Smoluchowski's equation. With initial conditions, it is called the Discrete Agglomeration Model. Several problems have been associated with this model allowing progress to proceed separately. To facilitate this progress, in this paper we develop and solve the Moment Problem (MP) for the autonomous quadratic kernel.

Stability in a Distributed Delay Differential Equation

Israel Ncube, *Alabama A & M University*

The subject of the presentation is the asymptotic stability analysis of the trivial equilibrium of a scalar and linear delay differential equation with two (infinite) distributed delays characterised by general delay kernels. The goal is to determine conditions on the parameters of the equation guaranteeing stability. The results are based on the exact analysis of the characteristic equation of the delay differential equation.

Metastable Decay of Nearest-Neighbor Ising Ferromagnets in the Hyperbolic Plane

Howard Richards, *Marshall University*

Monte Carlo simulations of the nearest-neighbor Ising ferromagnet and calculations show that metastable decay occurs very differently in the hyperbolic plane than in the Euclidean plane. In the hyperbolic plane there is true metastability, though that can perhaps be destroyed by open boundary conditions, and there is no distinction between single-droplet and multi-droplet decay. This research was supported by NSF grant OCI-1005117.

Multi-Target Shrinkage Estimation for Covariance Matrices

Tomer Lancewicki, *University of Tennessee*

Covariance matrix estimation becomes problematic when the number of samples is relatively small compared with the number of variables. We present a novel shrinkage estimator for covariance matrices that find a compromise between the sample covariance matrix and well-conditioned matrices with the aim of minimizing the mean-squared error (MSE). Numerical simulations demonstrate the effectiveness of the estimator. We also demonstrate the efficacy of the estimator by applying it to classification tasks.

CS2: Contributed Session II (Student Session)

Linear Elliptic Systems with Nonlinear Boundary Conditions Without Landesman-Lazer Conditions

Alzaki Fadlallah, *University of Alabama at Birmingham*

The boundary value problem is examined for the system of elliptic equations of from $-\Delta u + A(x)u = 0$ in Ω, where $A(x)$ is positive semidefinite matrix on $\mathbb{R}^{k\times k}$, and $\frac{\partial u}{\partial \nu} + g(u) = h(x)$ on $\partial\Omega$. It is assumed that $g \in C(\mathbb{R}^k, \mathbb{R}^k)$ is a bounded function which may vanish at infinity. The proofs are based on Leray-Schauder degree methods.

A Few Model Problems as Symmetric Positive Systems

Mohammad H Akanda, *Auburn University*

A symmetric positive system, also known as Friedrich's system, is a system of first-order partial differential equations endowed with symmetry and positivity properties. The system immediately delivers existence and uniqueness results. A wide range of model problems can be accommodated into this framework. We prove some new model problems such as variants of linear poroelasticity equation, simple fokker-plank equation , as Friedrich's systems. Both analysis and numerical results will be presented on each problem.

Numerical Analysis and Testing of a Fully Discrete, Decoupled Algorithm for MHD in Elsässer Variable

Muhammad Mohebujjaman, *Clemson University*

We consider a fully discrete, efficient algorithm for magnetohydrodynamic (MHD) flow that is based on the Elsässer variable formulation and a timestepping scheme that decouples the MHD system but still provides unconditional stability. We prove stability and optimal convergence of the scheme. Numerical experiments are given which verify predicted convergence rates of our analysis, show the results of the scheme match well the results found when the computation is done with MHD in primitive variable.

Application of the Reduced Basis Method to the Forward Problem of Hyperspectral Diffuse Optical Tomography

Rachel Grotheer, *Clemson University*

In this talk, we develop a reduced basis method approach to solve the forward problem in hyperspectral diffuse optical tomography (hyDOT). Our work is motivated by the computationally expensive image reconstruction problem in hyDOT which requires solving the forward problem hundreds of times. We show how the reduced basis method greatly improves the computational burden of the forward problem, and show initial results as to how this improves the efficiency of the inverse problem.

Method for Comparing Saliency Maps in Computer Vision

Ali Darwish, *University of Alabama at Birmingham*

We propose new comparison metric for assessing the quality of saliency map prediction techniques. Our approach solves the issue of low sensitivity to false negative rate in eye-fixations hits over the saliency map. Also, it does not require the real eye-fixations coordinates to be present for the comparison. The technique increases the accuracy in the visual saliency, which is very significant in several areas such as defense systems, computer vision, and in parallel computing

Towards a Diagnostic Tool for Facial Dysmorphia

Serdar Cellat, *Florida State University*

The aim of this study is to develop a diagnostic tool that can help clinicians identify and categorize different facial dysmorphic syndromes based on facial shape. We introduce a tool that is able to locate the key differences between families of shapes and classify them according to those dissimilarities. The tool potentially can be applied to facial data and help to differentiate and categorize craniofacial dysmorphic syndromes, as well as separate dysmorphic faces from the normal faces. The tool also contains a Monte Carlo optimization technique which is called the simulated annealing method.

CS3: Contributed Session III

Signal Flow Design Approach to Orthogonal Radix-2 DCT-DST Algorithms

Sirani M. Perera, *Daytona State College*

Commonly in theoretical computer science and electrical engineering perspective, signal flow designs are used to build devices to implement or realize classical or fast algorithms.

In this talk, sparse and orthogonal factorizations of completely recursive, radix-2, stable discrete cosine transformation (DCT), discrete sine transformation (DST), and their inverse transform algorithms are presented with their complexity. Based on sole algorithms for DCT I-IV or DST I-IV or their inverses, signal flow graphs are presented.

A Fast Algorithm for Computing Integration Matrices for Spectral Methods

Nguyen Hoang, *University of West Georgia*

A fast algorithm for computing spectral integration matrices for an arbitrary node distribution has been proposed. Formulas for computing integration matrices for several node distributions based on Chebyshev and Legendre polynomials have been derived. Numerical experiments to demonstrate the efficiency of the new algorithm on solving integral equations are included.

Computation of Energy Release Rate Using Non-Uniform Rataional B-Spline Geometrical Mapping Method with Multiple Patches

Hyunju Kim, *North Greenville University*

The geometrical mapping techniques based on NURBS were introduced to solve an elliptic boundary value problems containing a singularity. In the mapping techniques, the inverse function of the NURBS geometrical mapping generate singular functions as well as smooth functions by an unconventional choice of control points. We extend the application of the mapping techniques into materials which have multiple singularities or cracks by adopting the structure of multiple patches which were introduced in Isogeometric Analysis.

Sedimentation and Thermophoresis Effects in the Presence of Convection in Colloidal Suspensions

Mahmoud DarAssi, *Princess Sumaya University for Technology*

In this talk, we develop a reduced basis method approach to solve the forward problem in hyperspectral diffuse optical tomography (hyDOT). Our work is motivated by the computationally expensive image reconstruction problem in hyDOT which requires solving the forward problem hundreds of times. We show how the reduced basis method greatly improves the computational burden of the forward problem, and show initial results as to how this improves the efficiency of the inverse problem.

CS4: Contributed Session IV

Error Estimates for a Regularization of a Formulation of the Porous Medium Equation

Koffi Fadimba, *University of South Carolina Aiken*

We consider the equation

$$\frac{\partial(\phi S)}{\partial t} - \nabla \cdot (k(S)\nabla S) = Q(S) \qquad (1)$$

which is a more general form of the classical Porous Medium Equation (PME)

$$\frac{\partial S}{\partial t} - \triangle(Sm) = Q(S) \qquad (2)$$

In Equation (1), which is obtained through a mathematical modeling of an immiscible and incompressible two-phase flow through a porous medium (assuming here there is no transport), one often assumes that the porosity ϕ is either independent of the time variable or changes little with time. In this case one obtains the equation

$$\frac{\partial(S)}{\partial t} - \nabla \cdot (k(S)\nabla S) = Q(S) \qquad (3)$$

This can bring in some loss of information even when the product rule is used and the term $\frac{\partial \phi}{\partial t} S$ is buried in the righthand side. In this presentation, we consider the case where the porosity $\phi = \phi(x, t)$ is a function of both the spatial variable x and the temporal variable t. Because of the degeneracies ($k(0) = k(1) = 0$), we regularize the problem (1) in the usual way and derive error estimates for the regularization problem.

Two-phase Generalized Forchheimer Flows in Porous Media

Thinh Kieu, *University of North Georgia*

We derive a non-linear system of parabolic equations to describe the onedimensional two-phase generalized Forchheimer flows of incompressible, immiscible fuids in porous media, with the presence of capillary forces. We prove the existence of non-constant steady state solutions under relevant constraints on relative permeabilities and capillary pressure. A weighted maximum principle is proved with the weight function depending on the steady state. Utilizing this crucial property, we establish the corresponding weighted stability for the perturbation and derive long time estimates for its weighted L_1-norm. Moreover, the stability for velocities (on bounded intervals) is obtained by using Bernstein's estimate technique.

On the Physics of Incompressible Fluids

Jonas Holdeman

The Navier-Stokes equation would seem to be 'settled law' governing incompressible fluid flow. But is it? Does this differential-algebraic equation hide a more complex structure? An integro-differential equation perhaps? Is there a physical basis for this IDE, or is it a 'mathematical trick'? If a 'physical' basis, what would first-principles derivation entail?

How might this affect computation? Would this clarify or confuse physical and mathematical understanding? These intriguing questions and more will be addressed.

Effect of Round Cavities on Flow and Heat Transfer Characteristics in Converging Pipes: A Numerical Study

Khalid Alammar, *King Saud University*

Using the standard k-e turbulence model, a developing, steady two-dimensional turbulent flow inside straight and converging pipes was simulated with and without round cavities. Effect of cavities on flow and heat transfer characteristics was investigated. Uncertainty was approximated through validation and grid independence. The simulation revealed circulation within the cavities. Cavity boundaries were shown to contribute significantly towards turbulence production. Cavity presence was shown to enhance overall heat transfer while increasing pressure drop significantly across the pipe.

CS5: Contributed Session V

Modeling of Ischemia Reperfusion and Postconditioning

Daniel Fong, *U.S. Merchant Marine Academy*

Reperfusion (restoration of blood flow) after a period of ischemia (interruption of blood flow) can paradoxically place tissues at risk of further injury. Recent studies have shown that postconditioning (intermittent periods of occlusion applied during reperfusion) can reduce ischemia reperfusion injury. In this talk, we will present a mathematical model to describe the reperfusion and postconditioning process following an ischemic insult, treating the blood vessel as a two-dimensional channel lined with a monolayer of endothelial cells. This model is used to investigate how postconditioning affect the cell density, by varying the frequency of the pulsatile flow and the oxygen fluctuation at the inflowing boundary. This is a joint work with Linda Cummings (NJIT).

On the Coffee Stain Problem

Emre Esenturk, *University of Warwick*

The transport of solute in an evaporating droplet is a pivotal problem in additive manufacturing industry. Current theories predict complete transfer of all solute to the edge, known as the coffee stain effect. Experimentally, this is not quite the case since some solute accumulates in the interior. We present some results on the new modified model. The simplified physics is described by a system of coupled transport equations. Analysis of these equations will be discussed.

Mathematical Model of Electromigration-Driven Evolution of the Surface Morphology and Composition for a Bi-Component Solid Film

Mikhail Khenner, *Western Kentucky University*

A two PDEs-based model is developed for studies of a morphological and compositional evolution of a thermodynamically stable alloy surface in a strong electric field, assuming different and anisotropic diffusional mobilities of the two atomic components. The linear stability analysis of a planar surface and the computations (using the Method of Lines) of morphology coarsening are performed. It is shown that the conditions for instability and the characteristic wavelength and growth rate differ from their counterparts in a single-component film. Computational parametric analyses reveal the sensitivity of the scaling exponents to the electric field strength and to the magnitude of anisotropies difference.

Step-Flow Stability in the Presence of Electromigration During Evaporation

Nick Kirby, *Austin Peay State University*

A step-flow model of crystal growth is thermodynamically consistent if all of its motions are automatically consistent with the second law of thermodynamics. Such a thermodynamically consistent model for crystal growth is presented in which there is a drift velocity arising from the interaction between an electric current and atoms on a crystal surface (this interaction is called electromigration). A stability analysis is performed and discussed.

CS6: Contributed Session VI

High-Order Time-Stepping Through Rapid Estimation of Block Gaussian Quadrature Nodes

James Lambers, *University of Southern Mississippi*

The stiffness of systems of ODEs that arise from spatial discretization of PDEs causes difficulties for explicit and implicit time-stepping methods. Krylov Subspace Spectral (KSS) methods present a balance between the efficiency of explicit methods and the stability of implicit methods by computing each Fourier coefficient from an individualized approximation of the solution operator of the PDE. In this talk, an asymptotic study of KSS methods is performed in order to drastically reduce computational expense without sacrificing accuracy. Generalization to nonlinear PDE is also presented.

The Application of Homotopy Analysis Method for the Solution of Time-Fractional Diffusion Equation with A Moving Boundary

Ogugua Onyejekwe, *Indian River State College*

It is difficult to obtain exact solutions to most moving boundary problems. In this paper, we employ the use of Homotopy Analysis Method to solve time-fractional diffusion equation with a moving boundary condition. The comparison of the results obtained in this paper with those obtained with other numerical methods shows the validity of HAM (Homotopy Analysis Method). Maple 18 software was used to carry put the computations.

A Model Reduction Algorithm for Simulating Sedimentation Velocity Analysis

Hashim Saber, *University of North Georgia*

An algorithm for the construction of a reduced model is developed to efficiently simulate a partial differential equation with distributed parameters. The algorithm is applied to the Lamm equation, which describes the sedimentation velocity experiment. It is a large scale inverse model that is costly to evaluate repeatedly. Moreover, its high-dimensional parametric input space, compounds the difficulty of effectively exploring the simulation process. The proposed parametric model reduction is applied to the simulating process of the sedimentation velocity experiment. The model is treated as a system with sedimentation and diffusion parameters to be preserved during model reduction. Model reduction allows us to reduce the simulation time significantly and, at the same time, it maintains a high accuracy.

One Nonlinear Model Based on Maxwell System

TemurJangveladze, *Georgian Technical University, Tbilisi, Georgia and I. Vekua Institute of Applied Mathematics of I. Javakhishvili Tbilisi State University, Tbilisi, Georgia*, Zurab Kiguradze, *I. Vekua Institute of Applied Mathematics of I. Javakhishvili Tbilisi State University, Tbilisi, Georgia*, and Maia Kratsashvili, *Sokhumi State University, Tbilisi, Georgia*

The model which is based on Maxwell system that describes the electromagnetic field diffusion process into a substance is investigated. Large time behavior of solutions of corresponding initial-boundary value problems as well as numerical solution of considered problems are studied.

On One System of Nonlinear Multi-dimensional Partial Differential Equations

TemurJangveladze, *Georgian Technical University, Tbilisi, Georgia and I. Vekua Institute of Applied Mathematics of I. Javakhishvili Tbilisi State University, Tbilisi, Georgia*, Zurab Kiguradze, *I. Vekua Institute of Applied Mathematics of I. Javakhishvili Tbilisi State University, Tbilisi, Georgia*, Giga Asanishvili, *Georgian Technical University, Tbilisi, Georgia* and Giorgi Jangveladze, *I. Javakhishvili Tbilisi State University, Tbilisi, Georgia*

The multi-dimensional system of nonlinear partial differential equations is considered. In two-dimensional case this system describes process of vein formation in higher plants. Variable directions finite difference scheme is constructed. Absolute stability and convergence of this scheme are studied. Rate of convergence is given. Various numerical experiments are carried out. Comparison of numerical experiments with the results of the theoretical investigation is given too. The appropriate graphical illustrations are given.

Poster Session

Agent Based Modeling for Stock Markets

Orhan Akal, *Florida State University*

The dynamics of a financial stock market is studied. Multiple independent agents trade in the simulated stock market, and each agent is provided with a simple decision rule based on past price history, either as a momentum trader, long-term investor or speculator. As a result of these interactions the model reproduces the complex, quasi-random dynamics of stock prices in actual markets.

Variants of Linear Poroelasticity Equation as Symmetric Positive Systems

Mohammad H Akanda, Yanzhao Cao, and A. J. Meir, *Auburn University*

A symmetric positive system, also known as Friedrich's system, is a system of first-order partial differential equations endowed with symmetry and positivity properties. By construction, the system immediately delivers existence and uniqueness results. A wide range of model problems can be accommodated into this framework. We prove that a few variants of linear poroelasticity equation with different base variables, belongs to symmetric positive systems. We will also present numerical results for each variant.

Compressed Sensing in a Multilinear Sparse System of Genomic Interactions

Alexandra Fry, *University of Alabama at Birmingham*

The application of multilinear systems and compressed sensing on a biological model of viral replication will be discussed. This problem is motivated by the mathematical study of interactions among genes in cells. We show that a tensor restricted isometry property (TRIP) is necessary to find the unique sparse solution in the multilinear system. This solution can aid in drastically reducing the number of experiments needed to assess combinations of genes are necessary for viral replication.

Symmetric Tensor Outer Product Decomposition

Christina Glenn, *University of Alabama at Birmingham*

Tensor decomposition methods that decrease tensor complexity while lowering computational costs are in high demand. Symmetric Outer Product Decomposition (SOPD) factors a fully (partially) symmetric tensor into a number of rank-one symmetric tensors. Few numerical methods exist for finding the SOPD. The standard method, Alternating Least Squares (ALS), often yields wrong solutions. We propose a new iterative method for

SOPD called Partial Column-wise Least Squares (PCLS). Numerical examples are provided to compare the performance of PCLS to ALS for the SOPD.

A Recursive Iterative Preconditoner for Conjugate Gradient Algorithm

Ingyu Lee, *Troy University*

Consider a solution of systems of linear equations Ax=b when the matrix A is a symmetric positive definite. We solve the system of linear equations using a direct method (Cholesky Factorization) or a preconditioned iterative method (Preconditioned Conjugate Gradient). In this poster, we are presenting a new preconditioner based on the iterative recursion. Our limited experiments show that a recursive iterative preconditioner improves the convergence of a Conjugate Gradient algorithm.

Time-Domain Matched Interface and Boundary Methods for Transverse Electric Modes with Complex Dispersive Interfaces

Duc Nguyen, *University of Alabama, Tuscaloosa*

The material is dispersive when its permittivity or permeability are functions of frequency. Therefore, the dispersive material is often used to simulate the electromagnetic waves' movements in the complex environment such as in soils, rock, ice, snow, and biological tissue. As a result, it plays an important role in numerous electromagnetic applications. For instance, the ground penetrating radar (GPR) and microwave imaging for early detection of breast cancer are involved in dealing with dispersive soil and dispersive tissue respectively. It is known that the transverse electric (TE) Maxwell's equations with the presence of the dispersive media produce non-smooth and discontinuous solutions. We formulate the interface auxiliary differential equations (IADEs) to acquire evanescent changes of the field regularities along the interface. A novel matched interface boundary time-domain (MIBTD) based on the leapfrog scheme is proposed to rigorously implement the time-dependent jump conditions. Numerical tests indicate the second order of accuracy is achieved in both L_∞ and L_2 norms when dealing with the complex interfaces.

Global classical solutions to the vacuum free boundary problem of 1-D full Navier-Stokes equations with large initial data

Yaobin Ou, *Renmin University of China*

The global existence of classical solutions to the free boundary problems of one-dimensional full compressible Navier-Stokes equations with large initial data is established, when the density connects to the vacuum continuously. The novelty of this result is its global-in-time regularity in contrast to the previous results of global weak solutions.

An Unstructured Cell-Center Finite Volume Approach for Structural Dynamics

Mohamed Selim, *University of Alabama at Birmingham*

Most structural dynamics solvers are based on finite element method (FEM) while state-of-the-art fluid dynamics solvers are based on finite volume method (FVM). However, there is a multitude of physical problems combining fluid and solid mechanics where the use of the same numerical approach for both mediums would be beneficial. We will present a cell-centered FVM structural dynamics solver as a preface for coupling it with the in-house fluid dynamics solver targeting fluid-structure interaction applications.

Solving Differential Equations via An Exotic Integral Transform

John Vastola, *University of Central Florida*

Motivated by a problem in summation, we introduce an integral transform with properties similar to the Laplace and Fourier transforms. All entire functions, and large classes of continuous and meromorphic functions are transformable. Interestingly, because the transform of an entire function is related to the function's Taylor coefficients, analytic approximations of other functions can be constructed. Applications to differential equations, and physical problems (including some from classical mechanics, electrodynamics, and quantum mechanics) are considered.