GLSIAM 2018 CONFERENCE PROGRAM

8:10 am - 8:50 am	Registration, Breakfast and Coffee, outside the room STAT 101							
8:50 am - 9:00 am	Welcome Remarks, State Hall							
9:00 am - 9:50 am	Plenary Talk(Chi-Wang Shu, STAT 101)							
10:00 am - 10:50 am	Plenary Talk(David Lamb, STAT 101)							
10:50 am - 11:15 am	Coffee break, Stat Hall, area outside of STAT 101							
11:15 am - 12:30 pm	Morning sesstions							
	Session CT1 STAT 111	Session CT2 STAT 112	Session CT3 STAT 113	Session CT4 STAT 114	Session CT5 STAT 115	Session CT6 STAT 116	Session CT7 STAT 123	Session MS1 STAT 117
12:30 pm - 12:40 pm	Group Photo							
12:40 pm - 1:30 pm	Lunch							
1:30 pm - 2:20 pm	Plenary Talk(Sebastian Schreiber, STAT 101)							
2:30 pm - 3:20 pm	Plenary Talk(Patrick Louis Combettes, STAT 101)							
3:20 pm - 3:45 pm	Coffee break							
3:45 pm - 5:25 pm	Afternoon sesstions							
	Session MS1 STAT 117	Session MS2 STAT 111	Session MS3 STAT 112	Session MS4 STAT 113	Session MS5 STAT 114	Session MS6 STAT 115	Session MS7 STAT 116	

*STAT: Stat Hall
*CT: Contributed Talk
*MS:Minisymposium

There are 25 mins for each talk including the presentation and questions.
In each contributed talk section, we ask the first speaker to chair the section.
In minisymposia, organizers are going to chair their sections.

***CT: Contributed Talk**
***MS: Minisymposium**

Morning Sessions

CT1	**STAT 111**	**11:15 am - 12:30 pm**
11:15 am - 11:35 am	Xiaoming Zheng	Axisymmetric study of drop interface impact in viscous flow
11:40am - 12:00pm	Yang He	Local Discontinuous Galerkin Methods for the Khokhlov-Zabolotskaya-Kuznetzov Equation
12:05am - 12:25pm	Hengguang Li	3D Anisotropic Finite Element Methods

CT2	**STAT 112**	**11:15 am - 12:30 pm**
11:15 am - 11:35 am	Keegan Kirk	Analysis of a Space-Time Hybridizable Discontinuous Galerkin Method for Advection-Diffusion Problems on Evolving Domains
11:40am - 12:00pm	Sander Rhebergen	Hybridizable and embedded discontinuous Galerkin methods for the Stokes problem: Preconditioning
12:05am - 12:25pm	Tamas Horvath	A pointwise divergence-free, H(div)-conforming, space-time hybridizable discontinuous Galerkin method for the incompressible Navier-Stokes equations

CT3	**STAT 113**	**11:15 am - 12:30 pm**
11:15 am - 11:35 am	Fanchen He	Recovery-based discontinuous Galerkin method for the Cahn-Hilliard equation
11:40am - 12:00pm	Giselle Sosa Jones	Hybrizidable Discontinuous Galerkin Method for Linear Free Surface Problems

CT4	**STAT 114**	**11:15 am - 12:30 pm**
11:15 am - 11:35 am	Alaa Haj Ali	The One-Phase Bifurcation For The p-Laplacian
11:40am - 12:00pm	Mohamed Sulman	A moving mesh finite element method for Keller-Segel chemotaxis model
12:05am - 12:25pm	Andrew Ekstrom	Improving pathways for student success in Math and Science

CT5	STAT 115	11:15 am - 12:30 pm
11:15 am - 11:35 am	Adam Stinchcombe	Using Brownian Motion Processes to Compute the Electroneutral Limit of Electrodiffusion
11:40am - 12:00pm	T. C. Sun	Time Series Methods for Modeling and Simulation of Terrain Profiles
12:05am - 12:25pm	Kevin Lin	Combined Finite Element Analysis Method for Crack Detection

CT6	STAT 116	11:15 am - 12:30 pm
11:15 am - 11:35 am	Dao Nguyen	Optimal control of a perturbed sweeping process
11:40 am - 12:00 pm	Mustafa Aggul	An Efficient Defect Correcting Extrapolation Technique
12:05 am - 12:25 pm	Andrei Klishin	Mathematical Recasting of Integrated System Design Problems

CT7	STAT 123	11:15 am - 12:30 pm
11:15 am - 11:35 am	Zhi Li	Decentralized consensus algorithms and their relations to primal-dual methods
11:40 am - 12:00 pm	Buddhika Priyasad Sembukutti Liyanage	Stabilizing the Turbulence of Navier-Stokes Equations in L_p-based Sobolev and Besov Spaces
12:05 am - 12:25 pm	Christian Mueller	Proximal methods for Penalized M-Estimators

MS1 Stochastic Systems and Applications	STAT 117	11:15 am - 12:30 pm
11:15 am - 11:35 am	Dang Hai Nguyen	Stochastic Lotka-Volterra food chains
11:40 am - 12:00 pm	Trang Bui	Numerical methods for non-zero-sum stochastic differential investment and applications to reinsurance games
12:05 am - 12:25 pm	Husein Nasralah	Asymptotic approximation of optimal portfolio

Afternoon Sessions

MS1 Stochastic Systems and Applications	**STAT 117**	**3:45 pm - 5:25 pm**
3:45 pm - 4:05 pm	Thu Nguyen	Control performance of connected and automated vehicles with communication erasure channels.
4:10 pm - 4:30 pm	Huy Nguyen	Bounded law of iterated logarithm for sequences of blockwise independent random variables
4:35 pm - 4:55 pm	Nhu Nguyen	Permanence and extinction of certain stochastic SIR models perturbed by white noise
5:00 pm - 5:20pm	Caojin Zhang	Pollution control under a switching diffusion model

MS2 Fluid analysis and Related Topics	**STAT 111**	**3:45 pm - 5:25 pm**
3:45 pm - 4:05 pm	Asif Mahmood	Non-Newtonian Flow-Induced Deformation From Pressurized Cavities in Absorbing Porous Tissues
4:10 pm - 4:30 pm	Wasim Jamshed	Entropy analysis of TiO2Cu/ H2O Casson nanofluid with inclined Lorentz forces
4:35 pm - 4:55 pm	Javed Siddique	Non-Newtonian Flow in Deformable Porous Media- Modeling and Simulations of Compression Molding Process

MS3 Finite element method, spectral method, numerical analysis	**STAT 112**	**3:45 pm - 5:25 pm**
3:45 pm - 4:05 pm	Lewei Zhao	An Efficient Spectral-Galerkin Method for Quantum Optomechanical Hamiltonian System
4:10 pm - 4:30 pm	Beichuan Deng	Superconvergence points of spectral interpolations for fractional derivatives
4:35 pm - 4:55 pm	Nadun Dissanayake	The Radial Basis Function Method Applied to Groundwater Flow and Solute Transport Models
5:00 pm - 5:20pm	Hao Pan	Comparison of recovery technique for finite element method

MS4 **Finite element method, spectral method, optimal control, related topics**	**STAT 113**	**3:45 pm - 5:25 pm**
3:45 pm - 4:05 pm	Sara Pollock	Uniqueness of P1 finite element solutions of quasilinear PDE
4:10 pm - 4:30 pm	Dilek Erkmen	A Defect-Deferred Correction Method for Fluid-Fluid Interaction
4:35 pm - 4:55 pm	Jingwei Hu	A FAST SPECTRAL METHOD FOR THE BOLTZMANN COLLISION OPERATOR WITH GENERAL COLLISION KERNELS
5:00 pm - 5:20pm	Stefan Doboszczak	Necessary Conditions for Distributed Optimal Control of Linearized Compressible Flow

MS5 **Nonlinear PDEs, Optimal Control Theory, and Related Topics**	**STAT 114**	**3:45 pm - 5:25 pm**
3:45 pm - 4:05 pm	Siddhant Agrawal	Angled crested type water waves
4:10 pm - 4:30 pm	Michael Pokojovy	Global Well-Posedness and Exponential Stability for Heterogeneous Anisotropic Maxwell's Equations under a Nonlinear Boundary Feedback with Delay
4:35 pm - 4:55 pm	Buddhika Priyasad	Boundary Stabilization of the Turbulence of Navier-Stokes Equations in Lp-based Sobolev and Besov Spaces
5:00 pm - 5:20pm	Shuangjian Zhang	On concavity of the principal's profit maximization facing agents who respond nonliearly to prices

MS6 **DG method, spectral method, optimal control and Related Topics**	**STAT 115**	**3:45 pm - 5:25 pm**
3:45 pm - 4:05 pm	Yan Jiang	Energy Stable Discontinuous Galerkin methods for Maxwell's equations in nonlinear optical media
4:10 pm - 4:30 pm	Zhanjing Tao	A Sparse Grid Discontinuous Galerkin Method for The Vlasov-Maxwell Equations
4:35 pm - 4:55 pm	Puttha Sakkaplangkul	UNCONDITIONALLY STABLE FDTD OPERATOR SPLITTING METHODS FOR THE MAXWELL-LANDAU-LIFSHITZ-GILBERT EQUATIONS
5:00 pm - 5:20pm	Anqi Chen	An ultra-weak discontinuous Galerkin method for Schrodinger equation in one dimension

MS7 Discontinuous Galerkin methods for PDE	**STAT 116**	**3:45 pm - 5:25 pm**
3:45 pm - 4:05 pm	Xiangxiong Zhang	A high order accurate bound-preserving compact finite difference scheme for scalar convection diffusion equations
4:10 pm - 4:30 pm	Yang Yang	On the blow-up time of local discontinuous Galerkin method for Keller-Segel Chemotaxis model
4:35 pm - 4:55 pm	Nattaporn Chuenjarern	Local discontinuous Galerkin methods for convection-diffusion equations on overlapping meshes
5:00 pm - 5:20pm	Ziyao Xu	Local discontinuous Galerkin methods for convection-diffusion equations on overlapping meshes

Abstracts

Plenary Talk 1

Chi-Wang Shu, Brown University

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Title: High order positivity-preserving discontinuous Galerkin methods for steady state or implicit time discretization of linear hyperbolic equations

Abstract: High order discontinuous Galerkin (DG) methods are widely used in solving linear and nonlinear hyperbolic equations. One important property of such equations is positivity of their solutions, in the sense that if the data (initial condition, boundary condition, source terms) are positive then the solution stays positive. It is a challenge to maintain such positivity numerically for high order schemes. In the past few years, significant progress has been made to design positivity-preserving (PP) DG methods which maintain high order accuracy with explicit strong stability preserving time discretization. However, it is more challenging to design implicit time discretization or steady state DG solvers which have the same property. In this talk we will describe our recent research on designing high order PP DG methods for steady state or implicit time discretization of linear hyperbolic equations. (1) For time dependent problems with periodic boundary conditions, we design high order in space PP DG solver with backward Euler time discretization which can maintain high order spatial accuracy with a lower bound on the CFL number. This is a joint work with Tong Qin. (2) For steady state or time dependent problems with inflow boundary conditions, we design PP DG methods which can maintain high order accuracy. In two spatial dimensions this would involve an augmented DG space. This is a joint work with Dan Ling and Juan Cheng.

Plenary Talk 2

David Lamb, USARMY RDECOM TARDEC (US)

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Title: Improving Army Ground Vehicles: a success story of Applied Mathematics and Statistics

Abstract: Soldiers and marines in the theater of war depend on the vehicles designed and built by the U.S. Army and the American defense industry. As with many other industries, the military ground vehicle community has found modeling and simulation (M&S) to be a very valuable tool for the improvement of their vehicles. A lot of the new methods for improving military ground vehicles are based on M&S, instead of more traditional design-build- test-fix methods. Of course, modeling and simulation of military ground vehicles uses a lot of advanced mathematical and statistical techniques.

The scientists and engineers of the U.S. Army Tank-Automotive Research, Development and Engineering Center (TARDEC) in Warren, Michigan, are always improving ways to give our soldiers the tanks and trucks they deserve, the very best. You might be surprised by the variety of mathematics and statistics courses that play into this vital work. From linear algebra to differential equations, from probability distributions to copulas, from numerical methods to graph theory, there are dozens of branches of mathematics and statistics which are used by the M&S engineers.

This talk will show some of the challenges in the modeling of military ground vehicles, and highlight a few mathematical and statistical methods which are critical to making the Army better. We will focus on the exacting problem of protecting against an underbody blast, where the M&S is giving us the most "bang for the buck". Some discussion will also be included of the future where autonomy is expected to play a big role in military operations.

Plenary Talk 3

Sebastian Schreiber, University of California-Davis

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Title: Species coexistence in the face of uncertainty

Abstract: A long standing, fundamental question in biology is "what are the minimal conditions to ensure the long-term persistence of a population, or to ensure the long-term coexistence of interacting species?" The answers to this question are essential for identifying mechanisms that maintain biodiversity and guiding conservation efforts. Mathematical models play an important role in identifying potential mechanisms and, when coupled with empirical work, can determine whether or not a given mechanism is operating in a specific population or community. For over a century, nonlinear difference and differential equations have been used to identify mechanisms for population persistence and species coexistence. These models, however, fail to account for intrinsic and extrinsic random fluctuations experienced by all populations. In this talk, I discuss recent mathematical results about persistence and coexistence for models accounting for demographic and environmental stochasticity.

Demographic stochasticity stems from populations consisting of a finite number of interacting individuals. These dynamics can be represented by Markov chains on a countable state space. For closed populations in a bounded world, extinction in these models occurs in finite time, but may be preceded by long-term transients. Quasi-stationary distributions (QSDs) of these Markov chains characterize this meta-stable behavior. These QSDs correspond to an eigenvector of the transition operator restricted to non-extinction states, and the associated eigenvalue determines the mean time to extinction when the Markov chain is in the quasi-stationary state. I will discuss under what conditions (i) this mean time to extinction increases exponentially with "habitat size" and (ii) the QSDs concentrate on attractors of the mean field model of the Markov chain. These results will be illustrated with models of competing Californian annual plants and chaotic beetles.

On the other hand, environmental stochasticity stems from fluctuations in environmental conditions which influence survival, growth, and reproduction. These effects on population and community dynamics can be modeled by stochastic difference or differential equations. For these models, "stochastic persistence" corresponds to the weak* limit points of the empirical measures of the process placing arbitrarily little weight on arbitrarily low population densities. I will discuss sufficient and necessary conditions for stochastic persistence. These conditions involve Lyapunov exponents corresponding to the "realized" per-capita growth rates of species with respect to stationary distributions supporting subsets of species. These results will be illustrated with models of Bay checkerspot butterflies and rock-paper-scissor dynamics.

Plenary Talk 4

Patrick Louis Combettes, North Carolina State University

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Title: SELF-DUAL CLASSES OF NONEXPANSIVE OPERATORS IN NONLINEAR ANALYSIS AND OPTIMIZATION

Abstract: Duality plays a fundamental role in standard optimization theory and in its extensions to more general nonlinear analysis problems such as variational inequalities and monotone inclusions. The algorithmic structures underlying the numerical solution of such problems rely implicitly on classes of operators that possess certain self-duality features. Examples of self-dual classes of nonexpansive operators will be presented and their properties will be discussed. Various applications will be covered.

Contributed Talks

Xiaoming Zheng , Central Michigan University

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Title: Axisymmetric study of drop interface impact in viscous flow

Abstract: This work studies the effects of two dimensionless numbers, Reynolds number and Weber number, on the rebounding phenomena in the drop/interface impact problem in a viscous flow. A drop falls through a viscous liquid and then impacts a liquid interface at the bottom. The drop may break to a ring in the falling process. In the impact, the drop may rebound or coalesce on contact. In this numerical study, we assume the drop falling and impacting processes are axisymmetric. We use axisymmetric finite element level-set method and adaptive mesh to solve the Navier-Stokes equations to simulate this process. After extensive parameter studies, we find that there is a range of Weber numbers dependent on the Reynolds numbers, within which the drop rebounds, below which the drop would coalesce directly with interface, and above which the drop may break into a ring.

He Yang, Augusta University

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Title: Local Discontinuous Galerkin Methods for the Khokhlov-Zabolotskaya-Kuznetzov Equation.

Abstract: Khokhlov-Zabolotskaya-Kuznetzov (KZK) equation is a model that describes the propagation of the ultrasound beams in the thermoviscous fluid. It contains a nonlocal diffraction term, an absorption term and a nonlinear term. Accurate numerical methods to simulate the KZK equation are important to its broad applications in medical ultrasound simulations. In this paper, we propose a local discontinuous Galerkin method to solve the KZK equation. We prove the L2 stability of our scheme and conduct a series of numerical experiments including the focused circular short tone burst excitation and the propagation of unfocused sound beams, which show that our scheme leads to accurate solutions and performs better than the benchmark solutions in the literature.

Hengguang Li, Wayne State University

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Title: 3D Anisotropic Finite Element Methods

Abstract: A review of recent advances on 3D anisotropic mesh algorithms for singular PDEs elliptic equation.

Keegan Kirk, University of Waterloo

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Title: Analysis of a Space-Time Hybridizable Discontinuous Galerkin Method for Advection-Diffusion Problems on Evolving Domains

Abstract: Many important applications of fluid mechanics require the solution of time-dependent partial differential equations on evolving and deforming domains. Notable examples include the simulation of rotating wind turbines in strong air flow, wave impact on offshore structures, and arterial blood flow in the human body. In contrast to problems posed on fixed domains, numerical methods for advection dominated problems on evolving domains must satisfy the Geometric Conservation Law (GCL), a non-trivial feat.

A viable candidate proven to automatically satisfy the GCL is the space-time discontinuous Galerkin (DG) method. The problem is fully discretized in space and time instead of the typical method of lines treatment of time-dependent problems on fixed domains. This leads to an accurate scheme well suited to handle moving and deforming domains, but at a significant increase in computational cost in comparison to traditional time-stepping methods. Attempts to rectify this situation have led to the pairing of space-time DG with the hybridizable discontinuous Galerkin (HDG) method, which was developed solely to reduce the computational expense of DG. The combination of the two methods results in a scheme that retains the high-order spatial and temporal accuracy and geometric flexibility of space-time DG without the associated computational burden.

In this talk, we perform an a priori analysis of a space-time HDG method for the non-stationary advection-diffusion problem posed on a time-dependent domain. We discuss the derivation of anisotropic trace and inverse inequalities valid for moving meshes, which are essential tools for our analysis. Stability of the scheme is proven through the satisfaction of an inf-sup condition. Finally, we discuss the error analysis of the method and derive theoretical rates of convergence.

Sander Rhebergen, University of Waterloo
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Title: Hybridizable and embedded discontinuous Galerkin methods for the Stokes problem: Preconditioning

Abstract: Recently we introduced hybrid methods for the Stokes [1] and Navier-Stokes [2] problem. These methods are constructed such that the approximate velocity field is pointwise divergence free and H(div)-conforming. As a result, these discretizations are pressure-robust, compatible with discontinuous Galerkin discretizations of transport equations and, in the case of the Navier-Stokes problem, our method is locally conservative and energy stable.

Typical of these hybrid (HDG, EDG) methods, is the ease at which static condensation can be applied. This static condensation, in which degrees of freedom on the interior of a cell are eliminated, significantly reduces the size of the discrete problem. In this talk we will introduce optimal preconditioners for these statically condensed linear systems [3].

[1] S. Rhebergen and G.N. Wells, Analysis of a hybridized/interface stabilized finite element method for the Stokes equations. SIAM J. Numer. Anal., Vol. 55/4, pp. 1982-2003, 2017. https://doi.org/10.1137/16M1083839

[2] S. Rhebergen and G.N. Wells, A hybridizable discontinuous Galerkin method for the Navier-Stokes equations with pointwise divergence-free velocity field. J. Sci. Comput., 2018. https://doi.org/10.1007/s10915-018-0671-4

[3] S. Rhebergen and G.N. Wells, Preconditioning of a hybridized discontinuous Galerkin finite element method for the Stokes equations. Submitted, 2018. http://arxiv.org/abs/1801.04707

Tamas Horvath, University of Waterloo
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Title: A pointwise divergence-free, H(div)-conforming, space-time hybridizable discontinuous Galerkin method for the incompressible Navier-Stokes equations

Abstract: The space-time Discontinuous Galerkin (DG) method is an excellent method to discretize problems on deforming domains. This method uses DG to discretize both in the spatial and temporal directions, allowing for an arbitrarily high order approximation in both space and time. Furthermore, this method automatically satisfies the geometric conservation law which is essential for accurate solutions on time-dependent domains. We extend this method to a higher-order accurate hybridizable discontinuous Galerkin method for incompressible flows. This new discretization guarantees an H(div)-conforming, pointwise divergence-free velocity field on time-dependent simplicial meshes.

Fanchen He, University of Michigan, Ann Arbor
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Title: Recovery-based discontinuous Galerkin method for the Cahn-Hilliard equation

Abstract: Discontinuous Galerkin (DG) Method was developed in 1970s to solve partial differential equations numerically. Then in 1990s it began to be used for computational fluid dynamics (CFD) simulations. However, handling high-order derivatives, even the diffusion terms in Navier-Stokes equation, is a nontrivial task because the numerical solutions are represented by discontinuous piecewise polynomials. In the community of CFD, there are many schemes have been developed to treat the diffusion terms, like IP, BR2, LDG, HDG, etc. In 2005, a novel recovery-based discontinuous Galerkin method (RDG) was introduced by van Leer and Nomura for diffusion, where a polynomial of higher degree is reconstructed on the two adjacent elements. It achieved a surprising order of accuracy of 3p + 2 for even p and 3p + 1 for odd p in terms of cell-average error for the standard heat equation.

Here we illustrate how to extend the idea of recovery to partial differential equations with high order derivatives, say, biharmonic operator. We developed a RDG method for Cahn-Hilliard equations. To enable analysis of RDG schemes designed for non-linear problems, we suggested a new way to analyze the accuracy of RDG schemes by using Taylor expansion, and applied it to show the accuracy and stability of the RDG scheme developed for Cahn-Hilliard equation in one space dimension. Numerical experiments show that this scheme has property of superconvergence. And in the case of linear Cahn-Hilliard type equations in one space dimension, it?€?s more accurate than the scheme based on local discontinuous Galerkin (LDG) method. We also presented the two dimensional extension of this scheme in Cartesian mesh and corresponding numerical results.

Giselle Sosa Jones, University of Waterloo
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Title: Hybridizable Discontinuous Galerkin Method for Linear Free Surface Problems

Abstract: In this talk, we present the discretization of the free surface problem for irrotational flows with linearized boundary conditions using the Local Hybridizable Discontinuous Galerkin (L-HDG) method and the Interior Penalty Discontinuous Galerkin (IP-DG) method. The IP-DG case follows the work done by van der Vegt et al. in 2005. For the time discretization, we employ a BDF scheme. Through static condensation, the linear system to be solved on each time step in the HDG method is in general smaller than the one obtained with DG. Moreover, in L-HDG the gradient of the scalar variable converges with optimal rate, in contrast to IP-DG where the gradient converges sub-optimally. L-HDG also allows superconvergence of the scalar variable through local postprocessing. We show two different numerical tests, one where the analytical solution is known, and another one where we simulate waves generated by a wave maker. For the first case, we show the rates of convergence of both methods when using linear, quadratic and cubic polynomials.

Alaa Haj Ali, Wayne State University
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Title: The One-Phase Bifurcation For The p-Laplacian

Abstract: A bifurcation about the uniqueness of a solution of a singularly perturbed free boundary problem of phase transition associated with the p-Laplacian, subject to given boundary condition is proved in this paper. We show this phenomenon by proving the existence of a third solution through the Mountain Pass Lemma when the boundary data decreases below a threshold. In the second part, we prove the convergence of an evolution to stable solutions, and show the Mountain Pass solution is unstable in this sense.

Mohamed Sulman, Wright State University
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Title: A moving mesh finite element method for Keller-Segel chemotaxis model

Abstract: A moving mesh finite element method is presented for the numerical solution of the Keller-Segel chemotaxis model. The grid nodes are redistributed at each time level by a coordinate transformation so that the nodes are concentrated in the region of large solution variation. The coordinate transformation is computed as the optimal solution of the L^2 Monge-Kantorovich problem. An implicit finite element method is used to discretize Keller-Segel chemotaxis model. Numerical experiments are presented to demonstrate the performance of the proposed moving mesh finite element method.

Andrew Ekstrom, Oakland University
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Title: Improving pathways for student success in Math and Science

Abstract: Math and science are considered some of the hardest courses a student can take. Poor performance in these courses are a leading cause for students to drop out of college/university. By using student level data from Oakland University, Oakland Community College and Henry Ford College, we track the performance of students as they travel through their math and science classes. We can see that in many cases, the cards are stacked against the student. Using our student level data, we can create a model for predicting student performance and make suggestions that significantly improve student outcomes and student retention at no cost to the college or university.

T. C. Sun, Wayne State University
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Title: Time Series Methods for Modeling and Simulation of Terrain Profiles

Abstract: In this talk we shall present several statistical time series methods to model and to simulate terrain profiles. We shall also present a new method to characterize terrain roughness. These methods will be applied to two testing tracks.

Adam Stinchcombe, University of Toronto
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Title: Using Brownian Motion Processes to Compute the Electroneutral Limit of Electrodiffusion

Abstract: The Poisson-Nernst-Planck (PNP) equations can be used to describe cellular electrical activity. However, on domains where the space-charge layer is small, these equations are intractable and therefore it is useful to assume that the ionic solution is everywhere electrically neutral. The much more manageable electroneutral model results from a boundary layer analysis of the PNP equations. The electroneutral model consists of a drift-diffusion equation for each ionic concentration and boundary conditions on the cell membranes that relate the ion flux to transmembrane currents and capacitive currents. An elliptic equation and a jump condition on the cell membranes determine the electrostatic potential.

In this talk, I detail a numerical method to simulate the electroneutral model for intricate cell membranes geometries. A backward differentiation formula for the drift-diffusion equation results in elliptic equations in space that are solved using Brownian motion processes and the Feynman-Kac formula. This approach is easily parallelized, works well in three dimensions, and can handle complicated boundaries. In a naive formulation, solution values are computed at each point in space independently, which is terribly inefficient. This is overcome with function approximation and temporal difference learning borrowed from the reinforcement learning literature.

Kevin Lin, US Air Force Institute of Technology

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Title: Combined Finite Element Analysis Method for Crack Detection

Abstract: Validation of SHM systems for aircraft is complicated by the extent and number of factors for which the SHM system must demonstrate robust performance. Therefore, a time and cost efficient method for examining all the sensitive factors must be conducted. In this paper, we demonstrate the utility of using the simulation modeling environment to determine the SHM sensitive factors that must be considered in subsequent experiments to enable SHM validation. We demonstrate this concept by examining the effect of SHM system configuration and flaw characteristics on the response of a signal from a known piezoelectric wafer active sensor in an aluminum plate using simulation models of a particular hot spot. We derive the signal responses mathematically and through statistical design of experiments, determine the significant factors that affect the damage indices computed from the signal using only half the number of runs normally required. We determine that the transmitter angle is the largest source of variation for the damage indices considered, followed by signal frequency and transmitter distance to the hot spot. These results demonstrate that the use of efficient statistical design and simulation may enable a cost and time-efficient sequential approach to quantifying sensitive SHM factors and system validation

Dao Nguyen, Wayne State University

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Title: Optimal control of a perturbed sweeping process

Abstract: This talk deals with an optimal control problem for a perturbed sweeping (Moreau) process, where control function is in additive perturbations on the right-hand side of the dissipative differential inclusion without changing the moving set and merely measurable without any Lipschitzian. It should be emphasized that the velocity mapping in the differential inclusions under consideration is highly non-Lipschitz, unbounded, the control is just measurable and the perturbation is a nonsmooth function, which cannot be treated by means of known results in optimal control for differential inclusions. To overcome such principal issues, we develop the method of discrete approximations married with catching-up algorithm and combine it with appropriate generalized differential tools of modern variational analysis, which allows us to adequately replace the original optimal control problem by a sequence of well-posed finite-dimensional optimization problems whose optimal solutions strongly converge to that of the original controlled perturbed sweeping process. Then we use this direct method to obtain nondegenerate necessary optimality conditions for the so-called intermediate relaxed local minimum of the controlled sweeping process. Furthermore, the established necessary optimality conditions are illustrated by several examples.

Mustafa Aggul, Michigan Technological University
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Title: An Efficient Defect Correcting Extrapolation Technique

Abstract: A high accuracy method, defect correcting extrapolation technique (DCE), presented here deals with numerical singularities due to small diffusion coefficients. Although the same approach could be generalized for most of the PDEs involving laplacian terms with a small coefficient, this report gives a brief discussion of the approach applied to the Navier-Stokes Equations (NSE) at high Reynolds numbers. In contrast to existing defect correction methods, this approach uses extrapolation idea together with an artificial viscosity approximation of NSE to achieve high accuracy without reformulate. As a result, it requires roughly half of the computational cost needed for other methods to produce similar (or even lower) quality solutions; around 1% more computational time and very little extra memory beyond DNS with artificial viscosity are required. It can also increase the time accuracy while extrapolating for defect correction. After the first extrapolation, which mainly eliminates the error due to artificial viscosity, repeated extrapolations can be employed to increase the time accuracy even more. Simple theory and computational results demonstrate that the new approach, indeed, achieves the proposed accuracy at a much lower cost than existing methods, and it is easily extendable to higher order accuracy with high efficiency. In addition to simple theoretical reasoning, this report presents an analytical and a quantitative test verifying convergence rates and need of less computational time with the latter, and a qualitative test with 2 and 3D fluid past backward-forward facing step benchmark problem.

Andrei Klishin, Department of Physics, University of Michigan
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Title: Mathematical Recasting of Integrated System Design Problems

Abstract: Typical challenges in the design of modern integrated systems involve selecting a good layout for heterogeneous components, while trying to fulfill several different design objectives at the same time. Historically, such challenges have been cast into different mathematical forms, most commonly optimization problems. The last 20 years have seen a gradual shift to view large design problems instead as constraint-satisfaction problems and to look for sets of feasible solutions. In this work we cast design problems in terms of maximal-entropy statistical physics problems. Doing so doesn't just let us combine the best of the two previous approaches, but also allows us to tap into a rich arsenal of physics techniques, from studying the problem at any desired scale via coarse graining, to the characterization of architecture class robustness via materials physics language. We demonstrate the power of this approach on several arrangement problems from Naval Engineering, but this paradigm is applicable to a broad range of other design problems.

Zhi Li, Michigan State University
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Title: Decentralized consensus algorithms and their relations to primal-dual methods

Abstract: In decentralized consensus optimization, agents over a network collaboratively minimize the sum of private functions hold at all the agents. The agents exchange their intermediate solutions and finally reach an optimal consensus solution. In this talk, we introduce two decentralized algorithms and show how they are related to primal-dual methods. These connections are helpful in exploring the properties of the decentralized algorithms, thus we can provide the optimal upper bound for the stepsize of an existing algorithm EXTRA and propose a new algorithm NIDS. NIDS can choose a stepsize that is as large as the centralized ones, and the stepsize does not depend on the network topology. Numerical experiments demonstrate the proposed algorithms converge faster than some up-to-date approaches.

Buddhika Priyasad Sembukutti Liyanage, The University of Memphis
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Title: Stabilizing the Turbulence of Navier-Stokes Equations in L_p-based Sobolev and Besov Spaces

Abstract: We consider the 2- or 3-dimensional Navier-Stokes equations defined on a bounded domain, initially with no-slip boundary conditions and subject to a force. Such forcing term may cause turbulence. We the seek to uniformly stabilize the N-S system, either by an internal localized control or else possibly by a localized boundary tangential control. In either case, we aimed an explicitly constructed finite-dimensional control. Prior results in the Hilbert (L_2-based Sobolev) spaces. In the 3D boundary tangential case, finite dimensionality of the stabilizing control in the Hilbert setting is generally not possible (unless the initial condition vanishes on the boundary), as the N-S non-linearity for 3D forces the necessity of imposing compatibility conditions. Then we seek to solve the boundary tangential case in the context of L_p-based Sobolev spaces and Besov spaces, which don't impose compatibility condition. We begin with the interior stabilization to test the technique. The proof relies on many technical ingredients including:

1. recently developed maximal regularity theory for Stokes operators acting on L_p-based Sobolev and Besov spaces ,

2. and a unique continuation theorem developed for Oseen operators via appropriate Carleman-type estimates.

Christian Mueller, Flatiron Institute, Simons Foundation, New York
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Title: Proximal methods for Penalized M-Estimators (Patrick L. Combettes and Christian L. Mueller)

Abstract: We introduce a statistical model for penalized concomitant M-estimation that generalizes a large class of known statistical estimators, including Huber?€?s concomitant M-estimator, the scaled Lasso, and Support Vector Machine Regression. The model leverages the observation that convex concomitant estimators are instances of perspective functions. Perspective functions are amenable to proximal analysis and allow a principled construction of their proximity operators. Combining these proximity operators with splitting techniques leads to a unified algorithmic framework for global optimization of the proposed model.

Minisymposia

Dang Hai Nguyen, Wayne State University, Mathematics Department
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Title: STOCHASTIC LOTKA-VOLTERRA FOOD CHAINS

Abstract: We study the persistence and extinction of species in a simple food chain that is modelled by a Lotka-Volterra system with environmental stochasticity. There exist sharp results for deterministic Lotka-Volterra systems in the literature but few for their stochastic counterparts. The food chain we analyze consists of one prey and n ??? 1 predators. The jth predator eats the j ??? 1th species and is eaten by the j + 1th predator; this way each species only interacts with at most two other species - the ones that are immediately above or below it in the trophic chain. We show that one can classify, based on an explicit quantity depending on the interaction coefficients of the system, which species go extinct and which converge to their unique invariant probability measure. Our work can be seen as a natural extension of the deterministic results of Gard and Hallam ?€?79 to a stochastic setting. As one consequence we show that environmental stochasticity makes species more likely to go extinct. However, if the environmental fluctuations are small, persistence in the deterministic setting is preserved in the stochastic system. Our analysis also shows that the addition of a new apex predator makes, as expected, the different species more prone to extinction. Another novelty of our analysis is the fact that we can describe the behavior the system when the noise is degenerate. This is relevant because of the possibility of strong correlations between the effects of the environment on the different species.

Trang Bui, Wayne State University, Mathematics Department
Email:

Title: Numerical methods for non-zero-sum stochastic differential investment and applications to reinsurance games

Abstract:

Husein Nasralah, Wayne State University, Mathematics Department
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Title: Asymptotic approximation of optimal portfolio

Abstract: We study the problem of portfolio optimization in mathematical finance under the assumption of a stochastic volatility model for the stock price. Under general assumptions on the utility function, we construct an approximating portfolio which is close-to-optimal for small trading horizons. We end with a discussion on extending these small-time results to longer time horizons.

Thu Nguyen, Wayne State University, Mathematics Department
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Title: CONTROL PERFORMANCE OF CONNECTED AND AUTOMATED VEHICLES WITH COMMUNICATION ERASURE CHANNELS

Abstract: Connected and automated vehicles require integrated design of communications and control to achieve coordination of highway vehicles. Random features of wireless communications result in uncertainties in networked systems and impact control performance. Here we model switching network topologies by Markov chains and examine the impact of communication erasure channels on vehicle platoon formation and robustness under a weighted and constrained consensus framework. By comparing convergence properties of networked control algorithms under different communication channel features, we characterize some intrinsic relationships between packet delivery ratio and convergence rate. Simulation case studies are performed to verify the theoretical findings.

Huy Nguyen, Wayne State University, Mathematics Department
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Title: THE BOUNDED LAW OF THE ITERATED LOGARITHM FOR SEQUENCES OF BLOCKWISE INDEPENDENT RANDOM VARIABLES

Abstract: For a sequence of blockwise independent random variables $\{X_{n},n\geqslant 1\}$, conditions are provided to obtain the bounded law of the iterated logarithm. The main results are blockwise independent analogues of the (bounded) Kolmogorov law of the iterated logarithm and the (bounded) Hartman-Wintner law of the iterated logarithm.

Nhu Nguyen, Wayne State University, Mathematics Department
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Title: Permanence and extinction of certain stochastic SIR models perturbed by white noises

Abstract: In this paper, we study sufficient conditions for the permanence and ergodicity of a stochastic susceptible-infected-recovered (SIR) epidemic model with Beddington-DeAngelis incidence rate in both of non-degenerate and degenerate cases. The conditions obtained in fact are close to the necessary one. We also characterize the support of the invariant probability measure and prove the convergence in total variation norm of the transition probability to the invariant measure. Some of numerical examples are given to illustrate our results.

Caojin Zhang, Wayne State University, Mathematics Department
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Title: Pollution control under a switching diffusion model

Abstract:

Asif Mahmood, Penn State University, York
Email: aum54@psu.edu

Title: Non-Newtonian Flow-Induced Deformation From Pressurized Cavities in Absorbing Porous Tissues

Abstract: We investigate the behavior of a spherical cavity in a soft biological tissue modeled as a deformable porous material during an injection of non-Newtonian fluid that follows a power law model. Fluid flows into the neighboring tissue due to high cavity pressure where it is absorbed by capillaries and lymphatics at a rate proportional to the local pressure. Power law fluid pressure and displacement of solid in the tissue are computed as function of radial distance and time.

Wasim Jamshed, Penn State University, York
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Title: Entropy analysis of TiO2Cu/ H2O Casson nanofluid with inclined Lorentz forces

Abstract: In the present research a simplified mathematical model is considered in the form of non-uniform unsteady stretching surface. The flow is induced by a non-uniform stretching of the porous sheet and the uniform magnetic field is applied in the transverse direction to the flow. The non-Newtonian Casson fluid model is used along with slip boundary conditions. Moreover the high temperature effect of thermal radiation and temperature dependent thermal conductivity are also included in the present model. The mathematical formulation is carried out through a boundary layer approach and the numerical computations are carried out for Cu-water and TiO2-water nanofluids. Results are presented for the velocity, temperature and entropy generation profiles as well as the skin friction coefficient and Nusselt number and the discussion is concluded on the effect of various governing parameters on the motion, temperature variation, velocity gradient and the rate of heat transfer at the boundary.

Javed Siddique, Penn State University, York
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Title: Non-Newtonian Flow in Deformable Porous Media- Modeling and Simulations of Compression Molding Process

Abstract: The aim of our study is to develop mathematical model which can assist in improving industrial manufacturing of composite materials by compression molding process. Modeling is based on the uni-directional compression of preimpregnated ('prepreg') layers of deformable media filled with non-Newtonian fluid.The main idea is to use Eulerian coordinates and then Lagrangian coordinates fixed on solid preimpregnated pile, considering the dynamics controlled by pressure applied on the piston or velocity of piston.

Lewei Zhao, Wayne State University, Mathematics Department
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Title: An Efficient Spectral-Galerkin Method for Quantum Optomechanical Hamiltonian System

Abstract: We present in this paper an effficient spectral-Galerkin method for optomechanical Hamiltonian system. By separating the classical and quantum components, the quantum Langevin equations are rewritten as a classical scalar system of equations coupled to an approximate quantum equations. Then we introduce suitable Sobolev space and establish corresponding weak form and discrete scheme. In order to solve the nonlinear discrete scheme, we propose an iterative algorithm and construct an appropriate set of basis functions such that the matrices in the discrete variational form are sparse. Finally, we provide some numerical experiments to show the efficiency of the algorithms. This talk is based on joint work with Dr.Jing An and Dr.Wenzhao Zhang from Beijing Computational Science Research Center, China.

Beichuan Deng, Wayne State University, Mathematics Department
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Title: Superconvergence points of spectral interpolations for fractional derivatives.

Abstract:

Nadun Dissanayake, Michigan Tech University
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Title: The Radial Basis Function Method Applied to Groundwater Flow and Solute Transport Models

Abstract: This talk will focus on using the Finite Difference-based Radial Basis Functions (RBF-FD) method to solve groundwater flow and contaminant transport equations in a heterogeneous geological environment. With this procedure, we combine RBFs' strengths in representing complex geometries with its ability to accurately discretize differential operators, and attain a new robust modeling approach for stably and accurately computing the solution even in the vicinity of active wells, mathematically represented as singularities. We validate our method and verify its high order of accuracy by solving a well-known benchmark problem. Numerical results for groundwater flow equations in heterogeneous media will be presented and compared to results obtained with the USGS Finite Difference-based software MODFLOW that is customarily used by the geological community.

Hao Pan, Shandong Agricultural University
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Title: Comparison of recovery technique for finite element method

Abstract: In this talk, we compare four types recovery technique for gradient of finite element solution, local L^2 projection for gradient, local L^2 projection for function, superconvergence patch recovery(SPR), polynomial preserving recovery(PPR). Four translation-invariant mesh are presented, including regular, chevron, union-jack, criss-cross types. The fourth-order recovery for 3^{rd} polynomial PPR for linear element scheme is also demonstrated.

Sara Pollock, Wright State University
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Title: Uniqueness of P1 finite element solutions of quasilinear PDE

Abstract: We will discuss discrete comparison principles and uniqueness of solutions for a class of quasilinear elliptic partial differential equations. The comparison principle can be used in the finite element setting to establish uniqueness of the solution. We find for piecewise linear finite elements that without the presence of lower-order terms, it is sufficient for the meshsize to be locally controlled based on the difference between neighboring nodal values of the computed solution. We will consider a matrix analysis approach to obtain sharper conditions for the comparison principle.

Dilek Erkmen, Michigan Tech University
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Title: A Defect-Deferred Correction Method for Fluid-Fluid Interaction

Abstract: A method is proposed to improve two aspects of numerical simulations for a model of two fluids coupled across a flat interface. This problem is motivated by atmosphere-ocean interaction. A deferred correction approach lifts the numerical order of accuracy formally from first order (very common in applications) to second order, in terms of the time interval of communication between the fluid code components. This is accomplished in a two-step predictor-corrector type method. In the second step, a further defect correction is included as well. The “defect” represents artificial diffusion used in the fluid solvers, which is often included to control numerical noise or to model subscale mixing processes. The addition of the defect correction adds only marginally to the expense, but in exchange may provide a significant reduction of overdiffusive effects. The defect and deferred correction approaches are combined into a so-called defect-deferred correction (DDC) method. A full DDC algorithm is studied using finite elements in space, including an analysis of the stability and convergence. The method is unconditionally stable, optimally convergent and also enforces a formal reduction in artificial diffusion effects. A computational example using a known (manufactured) solution illustrates the theoretical predictions. We observe a computational benefit in this example even for coarse time steps and over a wide range of artificial viscosity values. Some discussion is provided regarding the possibility to generalize the approach for application codes. Briefly, legacy atmosphere and ocean codes may be used as-is over a coupling time interval for a predictor computation. The corrector step would then potentially be implemented as a straight-forward modification of the predictor step that leverages the existing code structure.

Jingwei Hu, Purdue University
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Title: A FAST SPECTRAL METHOD FOR THE BOLTZMANN COLLISION OPERATOR WITH GENERAL COLLISION KERNELS

We propose a simple fast spectral method for the Boltzmann collision operator with general collision kernels. In contrast to the direct spectral method [L. Pareschi and G. Russo, SIAM J. Numer. Anal., 37 (2000), pp. 1217-1245; I. M. Gamba and S. H. Tharkabhushanam, J. Comput. Phys., 228 (2009), pp. 2012-2036], which requires O(N^6) memory to store precomputed weights and has O(N^6) numerical complexity, the new method has complexity O(MN^4 log N), where N is the number of discretization points in each of the three velocity dimensions and M is the total number of discretization points on the

sphere and M \ll N^2. Furthermore, it requires no precomputation for the variable hard sphere model and only O(MN^4) memory to store precomputed functions for more general collision kernels. Although a faster spectral method is available [C. Mouhot and L. Pareschi, Math. Comp., 75 (2006), pp. 1833-1852] (with complexity O(MN^3 logN)), it works only for hard sphere molecules, thus limiting its use for practical problems. Our new method, on the other hand, can apply to arbitrary collision kernels. A series of numerical tests is performed to illustrate the efficiency and accuracy of the proposed method.

Stefan Doboszczak, Air Force Institute of Technology

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Title: Necessary Conditions for Distributed Optimal Control of Linearized Compressible Flow

Abstract: The compressible Navier-Stokes equations comprise a system of PDE describing the evolution of a linearly viscous compressible fluid. We consider the general problem of driving the fluid to a given state over a fixed time T, under the influence of a distributed control in the form of a body force. An optimal control is sought such that an integral cost functional is minimized. We first obtain the existence of optimal controls for the nonlinear system. Our result relies on the weak-strong uniqueness property of the compressible Navier-Stokes equations to ensure the existence of unique states. Next we obtain the first order necessary conditions for a linearized version of the compressible system in the form of a Pontryagin maximum principle.

Siddhant Agrawal, University of Michigan, Ann Arbor

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Title: ***Angled crested type water waves***

Abstract: We consider the two-dimensional gravity water wave equation with or without surface tension. We assume that the fluid is inviscid, incompressible and irrotational and the air density is zero. In the case of zero surface tension, we show that the singular solutions (which includes angled crested solutions) recently constructed by Wu are rigid. In the case of non-zero surface tension, we construct an energy functional and prove an a priori estimate without assuming the Taylor sign condition. This energy reduces to the energy obtained by Kinsey and Wu in the zero surface tension case for angled crest water waves. We show that in an appropriate regime, the zero surface tension limit of our solutions is the one for the gravity water wave equation which includes waves with angled crests.

Michael Pokojovy, The University of Texas at El Paso
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***Title:* Global Well-Posedness and Exponential Stability for Heterogeneous Anisotropic Maxwell's Equations under a Nonlinear Boundary Feedback with Delay**

Abstract: *We consider an initial-boundary value problem for the Maxwell's system in a bounded domain with a linear inhomogeneous anisotropic instantaneous material law subject to a nonlinear Silver-Mueller-type boundary feedback incorporating both an instantaneous damping and a time-localized delay mechanism. Using the maximal monotonicity property of the underlying nonlinear generator, we show the global well-posedness in an appropriate Hilbert space. Further, under suitable assumptions and geometric conditions, we prove the system is exponentially stable.*

Buddhika Priyasad, University of Memphis
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Title: Boundary Stabilization of the Turbulence of Navier-Stokes Equations in Lp-based Sobolev and Besov Spaces

Abstract: We consider the 3-dimensional Navier-Stokes equations defined on a bounded domain, subject to a force. Such forcing term may cause turbulence. We then seek to uniformly stabilize the N-S system, possibly by an explicitly constructed finite dimensional localized boundary tangential control in the feedback form. Prior results in the Hilbert (L2-based Sobolev) spaces. In the 3D boundary tangential case, the finite dimensionality of the stabilizing control in the Hilbert setting is generally not possible (unless the I.C. vanishes on the boundary), as the N-S non-linearity for 3D forces the necessity of imposing compatibility conditions. Then we seek to solve the boundary tangential case in the context of Lp-based Sobolev spaces and Besov spaces, which don't impose c. c. The proof relies on many technical ingredients including (i) recently developed maximal regularity theory for Stokes operators acting on Lp-based Sobolev and Besov spaces; (ii) a unique continuation theorem developed for Oseen operators via appropriate Carleman-type estimates.

Kelvin Shuangjian Zhang, University of Toronto
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Title: On concavity of the principal's profit maximization facing agents who respond nonliearly to prices.

Abstract: A monopolist wishes to maximize her profits by finding an optimal price policy. After she announces a menu of products and prices, each agent will choose to buy that product which maximizes his own utility, if positive. The principal's profits are the sum of the net earnings produced by each product sold. These are determined by the costs of production and the distribution of products sold, which in turn are based on the distribution of anonymous agents and the choices they make in response to the principal's price menu. In this talk, we describe a necessary and sufficient condition for the convexity or concavity of the principal's problem, assuming each agent's disutility is a strictly increasing but not necessarily affine (i.e. quasilinear) function of the price paid. Concavity when present, makes the problem more amenable to computational and theoretical analysis; it is key to obtaining uniqueness

and stability results for the principal's strategy in particular. Even in the quasilinear case, our analysis goes beyond previous work by addressing convexity as well as concavity, by establishing conditions which are not only sufficient but necessary, and by requiring fewer hypotheses on the agents' preferences. This talk represents joint work with my supervisor Robert McCann.

Yan Jiang, Michigan State University
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Title: Energy Stable Discontinuous Galerkin methods for Maxwell's equations in nonlinear optical media

Abstract: In this work, we focus on the propagation of electromagnetic waves in nonlinear optical media, which is modeled by the time-dependent Maxwell?€?s partial differential equations (PDEs) and a system of first order nonlinear ordinary differential equations (ODEs). To design efficient, accurate, and stable computational methods, we apply high order discontinuous Galerkin discretization in space to the hybrid PDE-ODE Maxwell system with several choices of numerical fluxes, and the resulting semi-discrete methods are shown to be energy stable. To achieve provable stability of fully discrete methods, novel strategies are proposed to treat the nonlinearity in our model within the framework of the second-order leap-frog and implicit trapezoidal time integrators. The performance of the overall algorithms are demonstrated through numerical simulations of kink and anti-kink waves, and third-harmonic generation in soliton propagation.

Zhanjing Tao, Michigan State University
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Title: A Sparse Grid Discontinuous Galerkin Method for The Vlasov-Maxwell Equations

Abstract: In this work, we develop a sparse discontinuous Galerkin (DG) scheme for the Vlasov-Maxwell equations in plasma simulations. Traditional DG scheme has too many degrees of freedom for high-dimensional simulations. To break the curse of dimensionality, the sparse grid method we developed is based on multiwavelets on tensorized nested grids and can significantly reduce the numbers of degrees of freedom. The accuracy and robustness of the scheme are validated by several numerical tests for Vlasov-Maxwell equations.

Puttha Sakkaplangkul, Michigan State University
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Title: UNCONDITIONALLY STABLE FDTD OPERATOR SPLITTING METHODS FOR THE MAXWELL-LANDAU-LIFSHITZ-GILBERT EQUATIONS

Abstract: We develop and analyze operator splitting methods for the Maxwell-Landau-Lifshitz-Gilbert system in two spatial dimensions: Sequential (SS) and Strang-Marchuck (SM) splitting methods. In one time step, each splitting scheme involves the solution of several, decoupled 1D Maxwell systems. We prove that both splitting schemes are unconditionally stable, preserve the modulus of the discrete magnetization, and satisfy a discrete energy decay property that mimics those of the continuum solution. The SS scheme is first (second) order accurate in time(space), while SM is second order accurate in both time and space. Numerical experiments and examples are given that illustrate and confirm our theoretical results.

Anqi Chen, Michigan State University
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Title: An ultra-weak discontinuous Galerkin method for Schrodinger equation in one dimension

Abstract: In this paper, we develop an ultra-weak discontinuous Galerkin (DG) method to solve the one-dimensional nonlinear Schrodinger equation. Stability conditions and error estimates are derived for the scheme with a general class of numerical fluxes. The error estimates are based on detailed analysis of the projection operator associated with each individual flux choice. Depending on the parameters, we find out that in some cases, the projection can be defined element-wise, facilitating analysis. In most cases, the projection is global, and its analysis depends on the resulting 2 by 2 block-circulant matrix structures. For a large class of parameter choices, optimal a priori L2 error estimates can be obtained. Numerical examples are provided verifying theoretical results.

Xiangxiong Zhang, Purdue University
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Title: a high order accurate bound-preserving compact finite difference scheme for scalar convection diffusion equations

Abstract: We show that the classical fourth order accurate compact finite scheme with high order strong stability preserving time discretizations for solving time dependent convection diffusion problems satisfies a weak monotonicity property, which implies that a simple three-point stencil limiter can enforce the bound-preserving property without losing conservation and high order accuracy. Higher order accurate compact finite difference schemes satisfying the weak monotonicity will also be discussed. For the two dimensional incompressible Navier-Stokes equations in the vorticity treamfunction form or any passive convection equation with a divergence free velocity field, we propose to compute a fourth order locally divergence free velocity field, with which the fourth order accurate compact finite difference scheme still satisfies the weak monotonicity thus the limiter can enforce the bound-preserving property.

Yang Yang, Michigan Technological University
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Title: On the blow-up time of local discontinuous Galerkin method for Keller-Segel Chemotaxis model

Abstract: In this talk, we apply local discontinuous Galerkin (LDG) method to solve Keller-Segel (KS) chemotaxis model. The KS chemotaxis model may exhibit blow-up patterns (delta-singularities) with certain initial conditions, and is not easy to approximate numerically. Especially, the exact blow-up time is very difficult to estimate. We will construct a strategy to compute the numerical blow-up time and theoretically prove that the liminf of the constructed numerical blow-up time is exactly the true one. Moreover, due to the high computational cost, adaptive method suitable for delta-singularities will be applied. Some numerical experiments will be given to demonstrate the convergence of the numerical blow-up time defined in this paper.

Nattaporn Chuenjarern, Michigan Technological University
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Title: Local discontinuous Galerkin methods for convection-diffusion equations on overlapping meshes

Abstract: Local discontinuous Galerkin (LDG) methods are popular for convectiondiffusion equations. In LDG methods, we introduce an auxiliary variable p to represent the derivative of the primary variable u, and solve them on the same mesh. In this talk, we will introduce a new LDG method, and solve u and p on different meshes. The stability and error estimates will be investigated. The new algorithm is more flexible and flux-free for pure diffusion equations without introducing additional computational cost compared with the original LDG methods, since it is not necessary to solve each equation twice. Moreover, it is possible to construct third-order maximum-principlepreserving schemes based on the new algorithm. However, one cannot anticipate optimal accuracy in some special cases. In this paper, we will find out the reason for accuracy degeneration by Fourier analysis which further leads to several alternatives to obtain optimal convergence rates. Finally, several numerical experiments will be given to demonstrate the stability and optimal accuracy of the new algorithm.

Ziyao Xu, Michigan Technological University
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Title: Local discontinuous Galerkin methods for convection-diffusion equations on overlapping meshes

Abstract: In this talk, we develop high-order bound-preserving (BP) discontinuous Galerkin (DG) methods for the coupled system of compressible miscible displacements on triangular meshes. We consider the problem with multi-component fluid mixture and the (volumetric) concentration of the jth component, cj , should be between 0 and 1. There are three main difficulties. Firstly, cj does not satisfy a maximum-principle. Therefore, the numerical techniques introduced in (X. Zhang and C.-W. Shu, Journal of Computational Physics, 229 (2010), 3091-3120) cannot be applied directly. The main idea is to apply the positivity-preserving techniques to all cj's and enforce Pj=1 cj = 1 simultaneously to obtain physically relevant approximations. By doing so, we have to treat the time derivative of the pressure dp dt as a source in the concentration equation and choose suitable fluxes in the pressure and concentration equations. Secondly, the construction of high-order BP schemes on triangular meshes. We use interior penalty DG methods for the concentration equations, and the first-order numerical fluxes are not easy to construct. Therefore, we will construct second-order BP schemes and then combine the second- and high-order fluxes to obtain a new one which further yields positive numerical cell averages. Finally, cj's are not the conservative variables, as a result, the classical slope limiter cannot be applied. Moreover, for fluid mixture with more than two components, we cannot simply set the upper bound of each cj to be 1. Therefore, a suitable limiter for multi-component fluid will be introduced. Numerical experiments will be given to demonstrate the high-order accuracy and good performance of the numerical technique.