Joint Midwest Numerical Analysis Day &
SIAM Great Lakes Numerical PDEs Spring Conference
April 17-18, 2009
Wayne State University, Detroit, MI

ABSTRACTS OF THE CONTRIBUTED TALKS

Spline element method for the Monge-Ampère equation

Gerard Awanou, Northern Illinois University
Saturday, April 18, 10:40–11:05, Room 1525

We consider numerical approximations of the Monge-Ampère equation $D^2u = f$ with Dirichlet boundary conditions on a convex bounded domain Ω in $\mathbb{R}^n, n = 2, 3$. Our method consists in using a variational formulation on the space $H^2(\Omega)$. We construct conforming approximations in the framework of the spline element method where the interelement continuities are enforced using Lagrange multipliers. The method is validated with numerical experiments for smooth solutions. For the case where the Monge-Ampère equation does not have a smooth solution, our experiments indicate that the viscosity solution is approximated. No proof of convergence is given in this case.

Sensitivity analysis to AFDE and transitions between microeconomic stability and non-equilibrium states

Ahmet Duran, University of Michigan, Ann Arbor
Friday, April 17, 4:10–4:35, Room 1525

I will present a parameter sensitivity analysis to the dynamical system of nonlinear asset flow differential equations (AFDE). I find that all parameters in AFDE are needed and can be estimated from market prices and net asset values data. The market price is the most fluctuating state variable and the coefficient for the trend-based investors' sentiment is the dominant parameter. Moreover, I observe that there are transitions between microeconomic equilibrium (stability) and non-equilibrium states because of the related large or small deviations from fundamental values and reversals (see Duran, Numerical Functional Analysis and Optimization, 2009).

Polynomial preserving recovery for quadratic elements on anisotropic meshes

Can Huang, Wayne State University
Friday, April 17, 4:35–5:00, Room 1525

Polynomial preserving gradient recovery technique under anisotropic meshes is further studied for quadratic elements. The analysis is performed for highly anisotropic meshes where the aspect ratios of element sides are unbounded. When the mesh is adapted to the solution that has significant changes in one direction but very little, if any, in another direction, the recovered gradient can be superconvergent. The results further explain why recovery type error estimator is robust even under non-standard and highly distorted meshes.

Numerical comparison of spectral collocation and symplectic methods on Hamiltonian dynamical systems

Nairat Kanyamee, Wayne State University
Friday, April 17, 5:15–5:40, Room 1525

The Hamiltonian dynamical systems have been an interest in many research areas. An ordinary numerical approximation of the systems, for example most of the Runge-Kutta methods, finite element method, finite difference method, is not structurally stable for a long-term behavior of the numerical solution. This work gives a comparison on numerical results of both linear and nonlinear Hamiltonian systems by using the Spectral Collocation method and Symplectic method. The spectral collocation method demonstrates an evidence of a better approximation on linear and nonlinear Hamiltonian systems. This is joint work with Prof. Zhimin Zhang.

Direct numerical simulations of a dispersed phase model to predict nanofluids heat transfer

Sasidhar Kondaraju, Wayne State University
Friday, April 17, 5:40–6:05, Room 1525

Nanofluids are the mixture of a very small volume fraction of nanoparticles in the fluid. Nanofluids were observed to enhance the heat transfer rates predominantly, when compared to base fluids. In this study, a dispersed phase numerical model is developed to predict the heat transfer in nanofluids. Direct numerical simulations are used to perform this analysis. Eulerian/Lagrangian scheme is employed, where fluid field is solved in the Eulerian co-ordinate system and particle simulations as carried upon in the Lagrangian co-ordinate system. Forces such as Brownian force, thermophoresis force and VandreWaals forces, which are predominant in the nanoparticles, are considered in the particle momentum equations. Fluid equations are solved using spectral methods involving Fast Fourier Transforms. Time integration is performed using third order Runge-Kutta scheme where nonlinear terms are solved explicitly and the linear terms are solved implicitly. Code is based on object oriented programming (OOP), in which the program objects are data grouping tightly coupled to procedures for operating on the data. Nanofluids with various volume fractions have been simulated and effective thermal conductivity ($k_{\text{nanofluid}}/k_{\text{basefluid}}$) of nanofluids is analyzed. Thermal conductivity of nanofluids is observed to be enhanced when compared to that of the base fluid. The values of thermal conductivity obtained from the simulations are in good agreement with the experiment values.

This is joint work with Prof. Joon Sang Lee, Wayne State Universtiy.

Stochastic computation under uncertainty

Jia Li, Purdue University, West Lafayette
Friday, April 17, 4:10–4:35, Room 1515

Uncertainty quantification (UQ) in stochastic computation has received intensive attentions in recent years. Quantifying the impact on system states by uncertainty in parameters, or initial/boundary conditions is essential to obtaining reliable simulation results and making estimations and predictions with high fidelity. UQ can be classified into two large categories: quantifying uncertainty within the mathematical model and quantifying the uncertainty between the model and reality. In this talk, the framework of UQ based on generalized polynomial chaos (gPC) will be reviewed. Latest efficient and accurate gPC based methods for both types of uncertainty quantifications will be presented. Error analysis results of the methods will be provided along numerical verifications.

Time domain mixed finite element methods for Maxwells equations in dispersive media

Jichun Li, University of Nevada, Las Vegas, and IPAM of UCLA
Saturday, April 18, 10:40–11:05, Room 1515

In the talk, we consider the time dependent Maxwells equations when dispersive media are involved. The Crank-Nicolson mixed finite element methods are developed for three most popular dispersive medium models: the isotropic cold plasma; the one-pole Debye medium; and the two-pole Lorentz medium. Optimal error estimates are proved for all three models solved by the Raviart-Thomas-Nedelec elements. Extensions to multiple pole dispersive media are discussed also. Preliminary numerical results will be presented. Some open problems will be addressed.

Electromagnetic scattering problems in a two-layered medium

Peijun Li, Purdue University, West Lafayette
Friday, April 17, 4:35–5:00, Room 1515

Scattering problems are concerned with the effect an inhomogeneous medium has on an incident wave, which are basic in many scientific areas such as radar and sonar, geophysical exploration, medical imaging. and near-field optical microscopy. In this talk, we consider a time-harmonic electromagnetic plane wave incident on an inhomogeneity embedded in a two-layered background medium. To apply numerical methods, the open domain needs to be truncated into a bounded domain. Therefore, a suitable boundary condition has to be imposed so that no artificial wave reflection occurs. Currently, much effort is devoted to the case of a homogeneous background medium and the development of boundary conditions for a layered one is still on-going. I will present a coupling of finite element and boundary integral equation method for the solution of electromagnetic scattering in both transverse electrical and magnetic polarization cases. The well-posedness of the continuous and discrete problems, as well as optimal error estimates for the variational approximation will be discussed. Numerical results will also be shown to illustrate the performance of the proposed method.

Surface phase separation and shape transition of a bio-membrane: a continuum model

Shuwang Li, Illinois Institute of Technology
Saturday, April 18, 11:05–11:30, Room 1525

Membranes considered here are composed of bilayer lipid molecules with hydrophilic heads and hydrophobic hydrocarbon chains. In an aqueous environment, bio-membranes form encapsulating bag-like shapes, called vesicles to reduce the energy of the hydrophobic edges. Membranes serve not only as outer boundaries that keep the structural integrity of cells, but also as interfaces that allow cells to communicate with their external environments. Because of its fluid-like nature and highly flexible structure, a vesicle adopts a wide variety of morphologies and exhibits rich shape transition behaviors.

In this talk, we develop a mathematical model to describe the dynamics of a membrane, in particular, the nonlinear coupling among flow, membrane morphology and the evolution of the surface phases. We will also discuss the associated numerical methods and some preliminary results. This is a joint work with John Lowengrub, J. Kim and Y.Tseng.

A Fourier series method for solving general boundary values problems

Wen Li, Wayne State University
Saturday, April 18, 11:30–11:55, Room 1525

A Fourier series method is developed for solving general boundary value problems. In this method, the solution is invariably expressed as a standard Fourier series supplemented by several sufficiently smooth functions to overcome the potential discontinuity problems at the boundaries. This solution method is demonstrated through solving the vibrations of arbitrarily restrained beams and plates which are governed by fourth-order differential equations. Mathematically, a series expansion is first constructed in such a way that it is able to represent any function (including the exact displacement solution) whose third-order (partial) derivatives are (required to be) continuous over the solution domain. Since the discontinuities potentially related to the first and third partial derivatives at the boundaries have been explicitly removed by the supplementary terms, all the series expansions for up to the fourth-order derivatives can be directly obtained through term-by-term differentiations of the solution series. Thus, a strong-form analytical solution can be obtained by letting the series simultaneously and exactly satisfy the governing differential equation and the boundary conditions on a point-wise basis. Because the series solution has to be truncated in actual calculations, the "exact solution" should be understood as a solution with an arbitrary precision. Several numerical examples are presented to illustrate the excellent accuracy and convergence of the Fourier series solutions. This method can be directly extended to general boundary value problems which involve, for instance, more complicated governing equations, boundary conditions, and/or coupling conditions.

A continuation method for the inverse source problem of the Helmholtz equation

Junshan Lin, Michigan State University
Saturday, April 18, 12:10–12:35, Room 1525

The inverse source problem of the Helmholtz Equation is investigated. We propose a continuation method which could successfully capture both the macro structures and the small scales of the source function. Numerical examples demonstrate the efficiency of the method.

Eulerian Gaussian beams for Schrödinger equations in the semi-classical regime

Jianliang Qian, Michigan State University
Saturday, April 18, 12:35–1:00, Room 1525

We propose Gaussian-beam based Eulerian methods to compute semi-classical solutions of the Schrödinger equation. Traditional Gaussian beam type methods for the Schrödinger equation are based on the Lagrangian ray tracing. Based on the first Eulerian Gaussian beam frameowrk proposed in Leung, Qian and Burridge (Geophysics 72(2007), SM61-SM76), we develop a new Eulerian Gaussian beam method which uses global Cartesian coordinates, level-set based implicit representation and Liouville equations. The resulting method gives uniformly distributed phases and amplitudes in phase space simultaneously. To obtain semi-classical solutions to the Schrödinger equation with different initial wave functions, we only need to slightly modify the summation formula. This yields a very efficient method for computing semi-classical solutions to the Schrödinger equation. For instance, in the one-dimensional case the proposed algorithm requires only $O(sNm^2)$ operations to compute s different solutions with s different initial wave functions under the influence of the same potential, where $N = O(1/\hbar)$, $\hbar$ is the Planck constant, and $m \ll N$ is the number of computed beams which depends on $\hbar$ weakly. Numerical experiments indicate that this Eulerian Gaussian beam approach yields accurate semi-classical solutions even at caustics. This is a joint work with Shingyu Leung at UCI.

Nonlinear tricomi equation as a conservation law - Numerical simulations via WENO schemes

Adrian Sescu, University of Toledo
Friday, April 17, 5:40–6:05, Room 1515

Nonlinear Tricomi equation is a hybrid (hyperbolic-elliptic) second order partial differential equation, modeling the sonic boom focusing. While the existent numerical methods solve the nonlinear Tricomi equation in pressure potential, in this work we adopt a direct solver in pressure, by transforming the hybrid equation into a hyperbolic conservation law. Weighted essentially non-oscillatory (WENO) schemes of third and fifth order of accuracy combined with third-order accurate total-variation diminishing (TVD) Runge-Kutta schemes are used to integrate the equation. To validate the numerical results, the analytical solution to the linear Tricomi equation is used for comparison.

Numerical Smoothing, instead of Numerical Stability

Tong Sun, Bowling Green State University
Saturday, April 18, 4:10–4:35, Room 1525

Lax Equivalence Theorem is considered to be the fundamental framework for the error analysis for the numerical solutions of initial value problems. In this talk we explain why one can replace numerical stability by numerical smoothing. In addition, we will explore the necessity of numerical smoothing, the advantages of numerical smoothing in nonlinear problems and complicated schemes, and adaptive algorithms enabled by a smoothing indicator.

Modeling and computation of the optical responses of a nano medium

Yuanchang Sun, Michigan State University
Saturday, April 18, 11:05–11:30, Room 1515

Light-matter interactions on the nanometer scale are at the heart of nano optics. The fact that some quantum effects begin to dominate on nanoscale makes nanostructures possess strikingly different optical properties from their bulk. This talk will consider the excitons and biexcitons confinement effects in an optically excited nanocrystal. Modeling and computational studies will be presented.

Recurrent dynamics in turbulent boundary layers

Divakar Viswanath, University of Michigan, Ann Arbor
Saturday, April 18, 11:30–11:55, Room 1525

Most of the energy dissipation around a car at 60 mph happens within a few millimeters of the surface. Those few millimeters correspond to the near-wall region of the turbulent boundary layer. The dynamics in the near-wall region is recurrent with break-up and re-formation of structures. We will describe computations that locate exact recurrences and discuss their significance for understanding turbulent boundary layers.

Seismic inverse scattering and illumination analysis of wave-equation imaging via a Helmholtz solver

Shen Wang, Purdue University, West Lafayette
Saturday, April 18, 12:10–12:35, Room 1515

Seismic imaging, which generally speaking, uses seismic data collected on the Earth surface to image the subsurface structure, has been a paradise application field of inverse problem and aroused curiosities of both applied mathematicians and geophysicists for several decades. The classical pre-stack time migration has been gradually replaced by wave equation imaging for complex geological medium. Thus, solution to the Helmholtz equation which is the wave equation in frequency domain plays the key role in exploration geophysics. In this research, we developed a completely new direct Helmholtz solver based on so-called multifrontal method. We have demonstrated that this new solver is more efficient, robust and storage-economic than previous solver based on multigrid method in wave equation imaging. With our Helmholtz solver, firstly, pre-stack depth migration image and finite frequency isochrones have been generated based on Born approximation. Secondly, we proposed an inverse scattering transform to produce artifact free common source image even in the presence of caustics. Then, sensitivity kernel which is the gradient of cost function in reflection tomography has been obtained. On the other hand, we also performed illumination analysis with curvelets which are the wave packets. We present a comprehensive framework for wave equation illumination analysis and introduce a target oriented illumination correction that simultaneously accounts for limited acquisition aperture and locally compensates for the so-called normal operator in inverse scattering to yield a true amplitude image of reflectivity or reflection coefficients. Various numerical tests and examples based on lens model have been displayed.

Robust structured multifrontal factorization and preconditioning for discretized PDEs

Jianlin Xia, Purdue University, West Lafayette
Saturday, April 18, 12:35–1:00, Room 1515

We present an approximate structured factorization method which is efficient, robust, and also relatively insensitive to ill conditioning, high frequencies, or wavenumbers for some discretized PDEs. Given a sparse symmetric positive definite discretized matrix A, we compute a structured approximate factorization $A \approx LL^T$ with a desired accuracy, where L is lower triangular and data sparse. This can be used in direct solution or preconditioning for linear systems. The method uses the idea that during the direct factorization of some discretized matrices, certain dense intermediate matrices have a low-rank property, or, their off-diagonal blocks can be approximated by compact low-rank matrices. In this paper, we organize the factorization with a supernodal version multifrontal method using nested dissection ordering of the matrix. Each dense intermediate matrix is formed explicitly and then partially factorized so that the leading factor is a hierarchically semiseparable matrix and the Schur complement remains dense. The use of explicit dense matrices makes the method much simpler than existing structured factorization methods. The overall factor remains structured and can be used to solve systems in nearly linear complexity. The factorization algorithm costs $O(rn \log_2 n)$, where n is the matrix size, and r is a parameter related to the tolerance and the problem. Schur complements are automatically compensated during the factorization so that LL^T always exists for any accuracy and has enhanced positive definiteness. No extra stablization is needed. The method also works well as a preconditioner even if the low-rank property is not highly significant. We demonstrate the reliability and effectiveness of the method with various applications, including elliptic problems, linear elasticity equations, Helmholtz equations, Maxwell equations, etc. This is joint work with Ming Gu, and Jie Shen.

A New Modified Newton Iterative Algorithm for Implicit Runge-Kutta Methods

Dexuan Xie, University of Wisconsin, Milwaukee
Saturday, April 18, 4:10–4:35, Room 1515

A time dependent nonlinear PDE equation is often approximated by a semi-discretization approach as a large scale system of stiff ordinary differential equations (ODE). Thus, developing efficient numerical stiff ODE solvers may have an important impact on the numerical solution of a nonlinear PDE problem. This talk will introduce a new modified Newton iterative algorithm that I developed recently for efficiently implementing a high order implicit Runge-Kutta (IRK) method, the s-stage Radau IIA method with $s = 3$, 5, and 7. The new algorithm is a novel approximation to the classical Newton method, and contains the new test rules for adaptively updating Jacobian matrices and selecting step sizes according to an estimation of the rate of convergence. A general analysis shows that the new modified Newton method has a faster rate of convergence than the current simplified Newton method (a widely-used scheme for implementing high order IRK methods) while each of its iterations can be calculated as efficiently as each simplified Newton iteration. Numerical results confirm the theoretical results, and show that the new algorithm can significantly speed up the implementation of the Radau IIA method in comparison to the well-known Radau IIA software package RADAU.

The Direct Discontinuous Galerkin (DDG) Methods for Diffusion with interface correction

Jue Yan, Iowa State University
Saturday, April 18, 4:35–5:00, Room 1525

In [1] we proposed a general numerical flux formula for the solution derivative, and developed the so-called direct discontinuous Gallerkin(DDG) method. However, the DDG method becomes less practical for polynomials with even degree ($k \geq 4$) since the jump of 4th order (or higher) derivatives is needed to obtain the optimal accuracy. In this talk, we will talk a refined DDG method by adding interface corrections. This way optimal $(k + 1)$th order of accuracy is obtained for any p^k elements with a simple form of numerical fluxes. The admissible parameter in the flux formulation is estimated, and penalty is shown to be necessary when jump of 2nd order derivatives is not included in the numerical flux. The refined DDG method is then extended to convection diffusion problems in both one and two dimensional settings. A series of numerical tests are presented to demonstrate the high order accuracy of the method.

[1] H. Liu and J. Yan, The direct discontinuous Galerkin methods (DDG) for diffusion problems, SIAM J. Numer. Anal., accepted 2008.

Reproducing kernels of generalized Sobolev spaces via a Greens function approach

Qi Ye, Illinois Institute of Technology
Saturday, April 18, 5:00–5:25, Room 1525

We use a vector distributional operator $\mathbf{P}$ to introduce a generalization of the classical L_2-based Sobolev spaces $\mathcal{H}^s(\mathbb{R}^d)$. The operator $\mathbf{P}$ consists of finitely or countably many distributional operators which may be of differential or even more general type. We find that certain proper full-space Green's functions G with respect to $L = \mathbf{P}^{*T}\mathbf{P}$ are conditionally positive definite functions. The generalized Sobolev space can then become a reproducing-kernel Hilbert space and its reproducing kernel can be computed via the related Green's function G. As an application of this theoretical framework we can use G to construct a multivariate interpolant $s_{f,X}$ to data sampled from a generalized Sobolev function f. In addition, we also discuss the optimal recovery and the error analysis of the interpolant $s_{f,X}$. Among other examples we show how the Gaussian function Φ can become the reproducing kernel $K(\mathbf{x}, \mathbf{y}) := \Phi(\mathbf{x} - \mathbf{y})$ of a generalized Sobolev space. This is joint work to Prof. Fasshauer.

Multiscale modeling for cardiac electrical dynamics with a space-time adaptive algorithm

Wenjun Ying, Michigan Technological University
Saturday, April 18, 5:40–6:05, Room 1525

Studying cardiac electrical dynamics, the electrical activities of the heart, can help us understand better the underlying mechanisms for some related cardiovascular heart diseases, which kill hundreds of thousands of people in the United States every year. In mathematical biology of the heart, the cardiac electrical dynamics can be modeled by singularly perturbed reaction-diffusion equations, coupled with a set of stiff ordinary differential equations. Using mathematical modeling, hypotheses can be tested and the dynamics can be investigated in ways that cannot be done experimentally or clinically given access to more information about the system. Because electrical waves in the heart involve multiple widely varying scales in both space and time, computer simulation of electrical dynamics have been limited to either small domains or to time durations that are short relative to that observed for realistic arrhythmias. The electrical wave fronts typically occupy only a small fraction of the domain, are very sharp (in space) and change very rapidly (in time) while, in the region away from the wave fronts, the electrical potential is much flat and changes slowly. With standard numerical methods on uniform grids, very small mesh parameters and very small timesteps must be used to correctly resolve the fine details of the sharp and rapidly changing wave fronts.

In this talk, I will present a space and time adaptive mesh refinement algorithm for multiscale modeling of the cardiac electrical dynamics. The adaptive algorithm solves the reaction-diffusion equations with coarse grids and large timesteps in the area where the electrical potential is flat and changes slowly. It places fine grids only in the region where the sharp electrical waves are located, and uses small timesteps only in the phases where the action potential changes very rapidly. The number of grid nodes and timesteps used with the adaptive algorithm is to some extent minimized. A novel aspect of the method is that it can be used with non-rectangular elements on domains with complex geometries. Numerical simulations will be presented in two space (2D) and three dimensions (3D) demonstrating the performance of the algorithm.

Stability for an inverse hyperbolic problem

KiHyun Yun, Michigan State University
Friday, April 17, 5:15–5:40, Room 1515

We will discuss an inverse problem of determining an unknown potential q in a wave equation via the Neumann to Dirichlet map. In the previous works, the technique inspired by Sylverster and Uhlmann was used to prove the uniqueness theorem and a Holder type stability result with exponent $\frac{1}{3} - \epsilon$ for the inverse problem. In this talk, we present more effective way to utilize the technique to obtain an improved nearly Lipschitz type stability estimate.

An implicit preconditioner for efficiently solving stiff ODE problems

Mazen Zarrouk, University of Wisconsin, Milwaukee
Saturday, April 18, 4:35–5:00, Room 1515

An $s-$stage implicit Runge-Kutta (IRK) method for solving a stiff ODE system requires the solution of a nonlinear system, $G(z) = 0$, of size $s \cdot d$, at each time step, where s is the number of stages and d is the size of the ODE system. Typically, the nonlinear system is solved iteratively by a "simplified" Newton method, in which one solves the associated linear systems with the same coefficient matrix $A = G'(0)$. The linear systems are solved directly by computing the LU-decomposition of A only once (per time step). The advantage in using an iterative linear solver is that it does not require assembling the matrix $G'(z)$ explicitly, but rather the matrix-vector product form $G'(z)v$, which can be approximated efficiently using a simple finite difference formula. To speed up the rate of convergence of the iterative linear solver, such as the stabilized bi-conjugate (BiCGSTAB) method, and the generalized minimal residual method (GMRES), we propose an implicit preconditioner, P, which approximates the inverse of the simplified Newton coefficient matrix A. The preconditioner P is computed iteratively using the Ben-Israel formula $P_{l+1} = (2I - P_l A)P_l$, with P_0 being a very sparse approximation of A^{-1}, with at most m nonzero entries in each column (m is small). P_0 is computed explicitly by minimizing the Frobenius norm $||AP_0 - I||_F$. P is set as an iterate P_l for some l ($l = 3$ is typically sufficient) and does not need to be computed explicitly but rather in the matrix-vector form Pv which requires 2^l matrix-vector products of the generic form P_0AP_0w which is cheap to compute since P_0 is sparse, and $Av = G'(0)v$ can be approximated by finite difference. The advantage of this preconditioner is that the computation of P_0 by minimizing $||AP_0 - I||_F^2 = \sum ||AP_0^j - e_j||_2^2$ can be decomposed into n independent least square minimization problems $\min ||AP_0^j - e_j||_2$, where P_0^j and e_j denote the jth column of P_0 and the standard Euclidean vector, respectively. To test our approach, we applied this scheme to a widely used IRK method, the $s-$stage Radau IIA with $s = 3$, by preparing a package in Fortran 90. We implemented two iterative linear solvers: BiCGSTAB and GMRES. In this talk, we describe this new algorithm in details and present some numerical results for illustration. This is a joint work with my advisor Dexuan Xie.

Geometry of ill-posed problems and their solutions

Zhonggang Zeng, Northeastern Illinois University
Saturday, April 18, 5:00–5:25, Room 1515

Arising frequently in sciences and engineering, ill-posed problems remain a challenge and a frontier in scientific computing. As what Kahan called "a misconception" about ill-posed problems, their solutions are believed to be infinitely sensitive to data perturbations and thus unfeasible for numerical computation. In fact, the hypersensitivity can be easily removed in many cases. In this talk we present a geometric perspective on the nature of ill-posed problems: They form Riemannian manifolds of positive codimensions and those manifolds are entangled in certain stratification structures. Such an observation leads to a "three-strikes" principle for reformulating the ill-posed problems and eliminating the hypersensitivity. We shall also present a novel two-staged strategy that is proven effective for solving ill-posed algebraic problems: Identifying the maximum codimension manifold followed by solving a least squares projection. In both phases of solving ill-posed problems, matrix computation naturally arises and numerical linear algebra plays an indispensable role.

Mixed local discontinuous Galerkin methods for singularly perturbed problems

Huiqing Zhu, Wayne State University
Saturday, April 18, 5:40–6:05, Room 1515

In this presentation, we consider mixed local discontinuous Galerkin (LDG) methods for singularly perturbed convection-diffusion problems on a two-dimensional domain. The mixed LDG discretization on a Shishkin mesh is introduced. We will present the error estimates for the approximation of the gradient. We will present numerical experiments to verify our theoretical results. This is joint work with Prof. Zhimin Zhang.
