Copper Country Summer Workshop on NA and IP
Titles and Abstracts

On occasion of the 70th birthday of Prof. David Colton

Michigan Tech. Houghton, MI, Aug. 12-14, 2013

1. Awanou, Gerard, University of Illinois at Chicago, awanou@uic.edu

   Title: Standard Lagrange elements for the numerical resolution of the Monge-Ampere equation

   Abstract: We propose a new discretization of the Monge-Ampere equation by C^0 finite elements. Error estimates and numerical results illustrate the validity of the approach.

2. Bacuta, Constantin, University of Delaware, bacuta@math.udel.edu

   Title: A Cascadic Algorithm for Saddle Point Problems

   Abstract: We design a cascadic multilevel algorithm for approximating variational formulations of symmetric saddle point systems. The algorithm is based on availability of a families of stable finite element pairs. On each fixed level (pair of discrete spaces) an efficient solver such us the gradient or the conjugate gradient algorithm is implemented. We use new formulas that relate iteration errors and computable residual quantities to impose efficient level change criteria. The first iteration on each new level uses information about the best approximation of the discrete solution from the previous level. The cascadic algorithm is designed to keep the iteration error close to expected discretization error. Numerical results supporting the efficiency of the method are presented for the Stokes system. The experiments show that the algorithm achieves optimal approximation properties by performing a non-increasing (small) number of iterations on each level. We use our general theory to introduce/review the "saddle point least-squares" method and relate it with the Bramble-Pasciak's least-squares approach. As a consequence, we design a cascadic least-squares iterative solver for the time harmonic Maxwell equations, that does not involve edge elements or spaces of bubble functions. This is joint work with Francisco Javier Sayas and Lu Shu.

3. Brenner, Susanne, Louisiana State University, brenner@math.lsu.edu

   Title: C^0 Interior Penalty Methods

   Abstract: C^0 interior penalty methods are discontinuous Galerkin methods for fourth order problems. In this talk we will discuss the formulation, error analysis, fast solution techniques of these methods and applications to boundary value problems, obstacle problems and optimal control problems.

4. Chanane, Bilal, King Fahd University of Petroleum & Minerals, chanane@kfupm.edu.sa

   Title: Boundary Control of Nonlinear Parabolic Equation

   Abstract: In this talk we shall use the transmutation approach to control a Nonlinear Parabolic Equation from the boundary. Few examples will be presented to illustrate the method.

5. Cui, Jintao, University of Arkansas at Little Rock, jxcui1@ualr.edu

   Title: A Nonconforming Finite Element Method for an Acoustic Fluid-Structure Interaction Problem

   Abstract: In this talk we discuss a nonconforming finite element approximation of the vibration modes of an acoustic fluid-structure interaction. Displacement variables are used for both the fluid and the solid. The numerical scheme is based on the irrotational fluid displacement formulation; hence it is free of spurious eigenmodes.

The method uses weakly continuous P_1 vector fields for the fluid and classical piecewise linear elements for the solid; and it satisfies optimal order error estimates on properly graded meshes. The theoretical results are confirmed by numerical experiments. This is joint work with Susanne C. Brenner, Aycil Cesmelioglu and Li-yeng Sung.

6. Cakoni, Fioralba, University of Delaware, cakoni@math.udel.edu

   Title: Transmission Eigenvalues in Inverse Scattering Theory

   Abstract: The transmission eigenvalue problem is a new class of eigenvalue problems that has recently appeared in inverse scattering theory for inhomogeneous media. This is a non-selfadjoint nonlinear eigenvalue problem which makes its mathematical investigation challenging and interesting. Transmission eigenvalues are related to the so-called "non-scattering" frequencies for which one can construct an incident wave that does not scatter by a given inhomogeneity. Such eigenvalues provide information about material properties of scattering media and can be determined from scattering data, hence can play an important role in a variety of problems in target identification. In this lecture we will survey the state-of-the-art of the transmission eigenvalue problem. In particular, we will describe how this problem arises in scattering theory, how transmission eigenvalues can be computed from scattering data and what is known mathematically about these eigenvalues. Our discussion will include the investigation of the transmission eigenvalue problem for anisotropic media, Faber-Krahn type inequalities and monotonicity properties for the real transmission eigenvalues, as well as asymptotic approaches to transmission eigenvalue problem.

7. Chow, Sum, Brigham Young University, schow@math.byu.edu

   Title: Numerical solutions to scattering problems

   Abstract: In several applications such as medical imaging, the model is well described by a Helmholtz equation of the form
   $$\nabla^2 f + \kappa^2(1+\gamma)f = 0$$
   over a sufficiently large cubical region V . The inverse problem of interest is concerned with the determination of the spatially varying quantity, which possesses a compact support inside V. Under fairly general conditions, we can show that the inverse problem has a unique solution γ for given f. We also propose an efficient iterative solution procedure for solving the inverse problem. This is done by first reformulating the Helmholtz equation as a Lippmann-Schwinger integral equation, then applying Fourier transform techniques based on sinc series and wavelet series, which leads to the computation of a sequence of one dimensional Fourier transforms. The resulting transformed integral equation is then solved by a indefinite convolution method with an exponential order of convergence. We present some numerical examples to illustrate our solution procedure. The work is joint with Frank Stenger, University of Utah and SINC, LLC, Bob Anderssen, CSIRO.

8. Ganesh, Mahadevan, Colorado School of Mines, mganesh@mines.edu

   Title : A model reduction algorithm for efficient simulation of a class of parametrized 3D electromagnetic forward models

   Abstract: Electromagnetic (EM) inversion based on Newton-type methods and under parametric variations require efficient forward solvers. We consider a parameterized multiple scattering forward EM model in three dimensions. The parameters in the model describe the location, orientation, size, shape, and number of scattering particles as well as properties of the input source field such as the frequency, polarization, and incident direction. The need for fast and efficient (online) simulation of the interacting scattered fields under parametric variation of the multiple particle surface scattering configuration is fundamental to several applications for design, detection, inversion, or uncertainty quantification.

   For such dynamic parameterized multiple scattering models, the standard discretization procedures are prohibitively expensive due to the computational cost associated with solving the full model for each online parameter choice. In this work, we propose an iterative offline/online reduced basis approach for a boundary element method to simulate a parameterized system of surface integral equations reformulation of the multiple particle wave propagation model.

The approach includes (i) a greedy algorithm based computationally intensive offline procedure to create a selection of a set of a snapshot parameters and the construction of an associated reduced boundary element basis for each reference scatterer and (ii) an inexpensive online algorithm to generate the surface current and scattered field of the parameterized multiple wave propagation model for any choice of parameters within the parameter domains used in the offline procedure. Comparison of our numerical results with experimentally measured results for some benchmark configuration demonstrate the power of our method to rapidly simulate the interaction of scattered wave fields under parametric variation of the overall multiple particle configuration.

9. Guo, Yukun, Harbin Institute of Technology, ykguo@hit.edu.cn

   Title: A time domain approach to the linear sampling method

   Abstract: This talk is concerned with an inverse scattering problem of time-dependent non-harmonic acoustic waves in an inhomogeneous medium. The support of the inhomogeneity is determined from measurements of causal scattered waves by using the linear sampling method in the time domain. The effectiveness of the method will be illustrated with several numerical examples of 2D and 3D.

10. Han, Weiming, University of Iowa

    Title: Variational Principles, A Posteriori Error Estimates and Differential Approximations in Radiative Transfer

    Abstract: The radiative transfer equation (RTE) arises in a wide variety of applications. The RTE is an integro-differential equation, with first-order differentiation with respect to the spatial variable and integration with respect to the direction variable. The work presented in this talk was motivated by research in biomedical imaging. We discuss weak formulations, variational principles, and dual formulations of the RTE and the parity equations, a posteriori estimates for numerical solution errors and modeling errors, and a family of differential approximations of the RTE.

11. He, Xiaoming, Missouri University of Science and Technology, hex@mst.edu

    Title: Parallel, non-iterative, multi-physics domain decomposition methods for time-dependent Stokes-Darcy system

    Abstract: There exist many important applications that involve a free flow and a porous medium flow occurring in separate but abutting domains, with the two flows coupled at the interface between the two domains. Such flows arise in surface water flows, subsurface oil and groundwater flows such as karst aquifers, and flows in a vuggy porous medium. An important model describing such coupled flows is the Stokes-Darcy system in which the Stokes and Darcy systems are used to model the free and porous medium flows, respectively. The two systems of partial differential equations are coupled through interface conditions applied at the interface between the two flows, enabling a better description of the physics compared to that possible with a single-system model. However, coupling the two constituent models leads to a very complex system.

    This presentation discusses two parallel, non-iterative, multi-physics, domain decomposition methods are proposed to solve a coupled time-dependent Stokes-Darcy system with the Beavers-Joseph-Saffman-Jones interface condition. For both methods, spatial discretization is effected using finite element methods. The backward Euler method and a three-step backward differentiation method are used for the temporal discretization. Results obtained at previous time steps are used to approximate the coupling information on the interface between the Darcy and Stokes subdomains at the current time step. Hence, at each time step, only a single Stokes and a single Darcy problem need be solved; as these are uncoupled, they can be solved in parallel. The unconditional stability and convergence of the first method is proved and also illustrated through numerical experiments. The improved temporal convergence and unconditional stability of the second method is also illustrated through numerical experiments.

12. Ji, Xia, Chinese Academy of Sciences, jixia@lsec.cc.ac.cn

    Title: A Multi-Level Method for Transmission Eigenvalues of Anisotropic Media

    Abstract: In this talk, we propose a multi-level finite element method for the transmission eigenvalue problem of anisotropic media. The problem is non-standard and non-self-adjoint with important applications in inverse scattering theory. We employ a suitable finite element method to discretize the problem. The resulting generalized matrix eigenvalue problem is large, sparse and non-Hermitian. To compute the smallest real transmission eigenvalue, which is usually an interior eigenvalue, we devise a multi-level method using Arnoldi iteration. At the coarsest mesh, the eigenvalue is obtained using Arnoldi iteration with an adaptive searching technique. This value is used as the initial guess for Arnoldi iteration at the next mesh level. This procedure is then repeated until the finest mesh level. Numerical examples are presented to show the viability of the method.

13. Jiang, Jingfeng, Michigan Technological University,

    Title: Forward and Inverse Problems in Ultrasound-based Quantitative Palpation Imaging

    Abstract: Manual palpation is an effective tool for initial detection of many lesions because changes in soft tissue hardness are usually related to onset of certain pathologies. However, manual palpation is limited to abnormalities close to the skin surface and may be highly subjective. These facts have persuasively argued for seeking digital palpation techniques in which tissue hardness can be quantitatively imaged for more sensitive detection and characterization of these abnormalities. In our research, widely available and inexpensive ultrasound imaging systems will be employed to measure internal tissue motion induced by external deformations (e.g. deformation applied by the ultrasound transducer at the skin surface of the breast). Based on a biomechanical model, tissue mechanical properties (Youngï£¡s modulus or hyperelastic parameters) can be subsequently reconstructed from the measured tissue motion field using an inverse problem approach. This inverse problem is formulated and solved as an optimization problem: determine the elastic material properties that when used in a forward finite element (FE) solver for a set of simulated displacement fields, gives the best match to the ultrasonically-measured displacement field(s). Initial clinical trial results in breast cancer differentiation and monitoring of thermal ablation therapy will be used to demonstrate clinical utility of this technique.

14. Layton, William, University of Pittsburg, wjl@pitt.edu

    Title: Algorithms for calculation of flow ensembles

    Abstract: There are many uncertainties inherent in numerical simulation of fluid flows. Calculation of an ensemble of p solutions deals with these inherent uncertainties to increase the window of predictability (by averaging), to estimate solution sensitivities, and to estimate the uncertainty in the result (by calculation of a PDF of the resulting solution). Further, Kalnay's bred-vectors algorithm, used to select a minimal set of ensemble members capturing maximal spread of the resulting forecast itself involves repeated ensemble flow simulations. One common way to calculate these ensembles is to treat them as separate tasks, requiring computational effort and memory p-times the amount required for one simulation. If available memory is sufficient to treat the tasks in parallel, then the turnaround time is not increased, while if not then the turnaround time is multiplied by p. This talk presents a new approach intermediate between these two extremes which requires a negligible storage increase over one simulation (p solution vectors) and could have run time reduced over p successive simulations, depending on the block solver used and the time step condition required for stability. Thus the method is a new way to rebalance "the competition between high-resolution, single deterministic forecasts and ensembles" (Stensrud 2009). The times tep condition degenerates as the Reynolds number increases. However, we shall also show that by including a new parameterization of turbulence that is both more direct and more accurately captures the essential physics, the combination that results is unconditionally stable.

15. Li, Hengguang, Wayne State University, hli@math.wayne.edu

    Title: Regularity and Multigrid Analysis for Laplace-Type Axisymmetric Equations

    Abstract: We discuss new high-order full regularity estimates in weighted Sobolev spaces for a class of 2D equations reduced from 3D Poisson's equation on axisymmetric domains. Based on these estimates, we develop high-order finite element methods that approximate singular solutions of these equations in the optimal rate. Then, we show our analysis on the condition number of the system from the finite element discretization. This, together with our results on the approximation properties of the finite element solution and the smoothing properties of the smoother in the multigrid V-cycle algorithm, will lead to the uniform convergence of the multigrid method for the axisymmetric equations.

16. Li, Peijun, Purdue University, lipeijun@purdue.edu

    Title: Near-Field Imaging of Infinite Rough Surfaces

    Abstract: This talk is concerned with an inverse infinite rough surface scattering problem in near-field optical imaging, which is to reconstruct the scattering surface with a resolution beyond the diffraction limit. The surface is assumed to be a small and smooth deformation of a plane surface. Based on a transformed field expansion, the boundary value problem with complex scattering surface is converted into a successive sequence of a two-point boundary value problems in the frequency domain, where an analytic solution for the direct scattering problem is derived from the method of integrated solution. By neglecting the high order terms in the asymptotic expansion, the nonlinear inverse problem is linearized and an explicit inversion formula is obtained. The method works for sound soft, sound hard, and impedance surfaces, and requires only a single illumination at a fixed frequency and is realized efficiently by the fast Fourier transform. Numerical results show that the method is simple, stable, and effective to reconstruct scattering surfaces with subwavelength resolution.

17. Liao, Wenyuan, University of Calgary, Alberta, Canada, wliao@ucalgary.ca

    Title: Solving full-waveform inversion problem through PDE-constrained optimization

    Abstract: Full-waveform inversion (FWI) is a model-based data-fitting technique that has been widely used to estimate the medium property in Geophysics community for the purpose of hydrocarbon exploration. Given the large size of observational seismic data, and the iterative nature of the numerical procedure, FWI is computationally intensive, moreover, such inverse problem is ill-posed in general. Various numerical and theoretical strategies can be used to improve the well-posedness. In this work we formulate the FWI of cross-well seismic data as a PDE-constrained optimization problem, which is solved by the popular adjoint state method. The objective functional to be minimized is defined as the square norm of the misfit between observational data and modeled data based on an initial model, while the model parameter to be recovered is the acoustic velocity, which appears as the coefficient in the seismic wave equation. The issues that we attempt to address here include the creation of a reliable initial model, gradient calculation method for instance the automatic differentiation tools and gradient-based optimization algorithms. Some preliminary numerical results are presented to demonstrate the effectiveness and efficiency of the proposed numerical approach.

18. Liu, Di, Michigan State University, richarddiliu@gmail.com

    Title: Multiscale modeling and computation of nano optical responses

    Abstract: We introduce a new framework for the multiphysical modeling and multiscale computation of nano-optical responses. The semi-classical theory treats the evolution of the electromagnetic field and the motion of the charged particles self-consistently by coupling Maxwell equations with Quantum Mechanics. To overcome the numerical challenge of solving high dimensional many body Schrodinger equations involved, we adopt the Time Dependent Current Density Functional Theory (TD-CDFT). In the regime of linear responses, this leads to a linear system of equations determining the electromagnetic eld as well as the current and electron densities simultaneously. A self-consistent multiscale method is proposed to deal with the well separated space scales. Numerical examples are presented to illustrate the resonant condition.

19. Liu, Hongyu, UNCC, hliu28@uncc.edu

    Title: Locating multiple multi-scale electromagnetic scatterers

    Abstract: We shall describe an inverse scattering scheme of locating multiple multi-scale electromagnetic scatterers. The EM scatterers my consist of multiple components and each component could be either a penetrable inhomogeneous medium and an impenetrable PEC obstacle. Moreover, they may include, at the same time, both components of small size and regular size compared to the detecting EM wavelength. Most of the time, we shall make use of only a single far-field measurement. The scheme is based on a series of novel indicator functions.

20. Ren, Kui, University of Texas at Austin, ren@math.utexas.edu

    Title: Inverse coefficient problem for transport in stochastic environments

Abstract: We consider here an inverse coefficient problem for radiative transport in random media. We assume that the media properties to be reconstructed consists of two components: a deterministic component and a random component. We are interested in reconstructing the deterministic component. We show that the presence of the (unknown) random component (even with small amplitude) can cause significant error in the reconstruction of the deterministic component, statistically. We then present a method to reduce the variance of the coefficient reconstruction. Numerical simulations based on synthetic data will be presented.

21. Scotland, John, University of Michigan, jcsch@umich.edu

    Title: TBD.

22. Stefanov, Plamen, Purdue University, stefanov@math.purdue.edu

    Title: The identification problem in SPECT-theory and numerics

    Abstract: We consider the problem of recovery both the source and the attenuation of the attenuated X-ray transform in the plane. We review the recent theoretical results and present numerical reconstructions (joint work with Luo and Qian) demonstrating both the instability and the stability of the reconstruction, depending on the configuration.

23. Struthers, Allan, struther@mtu.edu Michigan Technological University

    Title: Contour Integral Based Algorithms for Interior Transmission Eigenvalues

    Abstract: Recent algorithms for various eigenvalue problems approximate invariant subspaces using resolvents. The distinctive features of these algorithms is that they can count and directly compute interior generalized and quadratic eigenvalues in specific locations in the complex plane for general matrices using various contour integral based projection algorithms.

    These algorithms are sufficiently recent that many implementation issues remain to be determined and resolved. This talk will discuss our experience implementing these algorithms to compute interior transmission eigenvalues arising from finite element discretizations of the underlying PDEs.

24. Sun, Tong, Bowling Green State University, tsun@bgsu.edu

    Title: Numerical smoothness for PDE error analysis

    Abstract: Numerical smoothness is an innovative concept proposed by the speaker. It will fundamentally improve the understanding about the error analysis of numerical PDEs, especially for time-dependent problems. The talk will explain (1) the concept of numerical smoothness; (2) the necessity of numerical smoothness in PDE error analysis; and (3) the relationship between numerical smoothness and numerical stability. Some error analysis results on nonlinear conservation laws will be presented, which will show the advantages of the error analysis methodology based on the numerical smoothness concept. New research results will be presented along with a list of open research topics.

25. Sung, Li-yeng, Louisiana State University, sung@math.lsu.edu

    Title: P1 Finite Element Methods for Two Dimensional Time Harmonic Maxwell Equations

    Abstract: The boundary value problem for the time harmonic Maxwell equations on two dimensional domains with the perfectly conducting boundary condition can be reduced to boundary value problems for the Laplace operator with either Dirichlet or Neumann boundary conditions. In this talk we will discuss adaptive P1 finite element method and multilevel P1 finite element method for the Maxwell equations that are based on this reduction. This is joint work with S.C. Brenner, J. Cui, Z. Nan and J. Gedicke.

26. Stuff, Mark, Michigan Tech Research Institute, mark.stuff@mtu.edu

    Title: Approaches to some non-linear inverse problems, motivated by ranging remote sensing methods

    Abstract: The desire to understand range (or travel time) dependent signals (from radar, sonar, seismic, ultrasound, etc) reflected from objects which have unknown motions, leads to some Euclidean geometry problems.

These require the determination of geometric configurations from partial information. Methods of attack include coordinate based approaches, invariance theory, and matrix completions. The best methods, with respect to computational complexity and sensitivity to noise, seem to be not yet discovered. But insights can be gained from experiments with algebraic solutions of invariant equations, numerical optimization methods, matrix completion methods, and fixed point iterations. Also, the extraction of range information from some of these signals motivates a desire for better methods for solving certain variational (optimal path finding) problems. Our current approach raises numerical issues related to repeated interpolations.

27. Synyavskyy, Andriy, Physico-Mechanical Institute of the National academy of Sciences of Ukraine, Lviv, Ukraine, a.synyavskyy@gmail.com

    Title: A linear sampling method for visualization of the boundary of an impenetrable object using near-field scattering data

    Abstract: A linear sampling method based on a new indicator function is the main subject of discussion. Numerical results for the solution of inverse scattering problem show that the new indicator function blows up at boundary unlike the known sampling methods (such as the linear sampling method, factorization method etc.), which allows to determine support of the scatter. Derivation of the indicator function is based on an idea of reconstruction of secondary fictive sources distributions, which are excited on the surface of an impenetrable scatter as a consequence of wave impinging. Stochastic approach is used to justify theoretically a blowing-up effect on the boundary, which is the characteristic of the indicator function. Collecting scattering data consists in multiple random excitations of the scatter surface. Consequently, the problem is formulated as the determination of an estimate of unknown random parameter starting from the scattering data. The estimate is derived as a solution of a finite dimensional linear set of equations for each sampling point. Even though a continuous counterpart of the method has not yet been theoretically established, multifrequency version of this linear sampling method demonstrates promising results. Numerical results include also a sensing scenario with partial aperture near-field scattering data as well as comparison of this method with other sampling method.

28. Xing, Yulong, University of Tennessee, xingy@math.utk.edu

    Title: Energy conserving discontinuous Galerkin methods for the wave propagation problems

    Abstract: Wave propagation problems arise in a wide range of applications. The energy conserving property is one of the guiding principles for numerical algorithms, in order to minimize the phase or shape errors after long time integration. In this presentation, we develop and analyze a local discontinuous Galerkin (LDG) method for solving the wave equation. We prove optimal error estimates and the energy conserving property for the semi-discrete formulation. The analysis is extended to the fully discrete LDG scheme, with the energy conserving high order time discretization. Numerical experiments have been provided to demonstrate the optimal rates of convergence. We also show that the shape of the solution, after long time integration, is well preserved due to the energy conserving property.

29. Xu, Liwei, Chongqing University, China, xuliwei95@gmail.com

    Title: Variational Methods for the Fluid-Structure Interaction Problem

    Abstract: We are concerned with numerical solutions for the interaction problem of plane acoustic waves in a compressible, inviscid fluid with an elastic structure. The mathematical model can be formulated by a coupling system of the time-harmonic Navier equation in the elastic domain and the Helmholtz equation in the fluid region with appropriate transmission conditions at the interface. We investigate numerical solutions of the problem based on finite element method and boundary integral equation methods. Essential theoretical analysis for numerical models and numerical solutions will be discussed. This is a joint work with Mr. Tao Yin at CQU, Prof. George C. Hsiao at U of Delaware, and Prof. Joseph E. Pasciak at TAMU.

30. Yang, Yang, Michigan Tech, yyang7@mtu.edu

    Title: Discontinuous Galerkin method for hyperbolic equations involving δ-singularities

    Abstract: We develop and analyze discontinues Galerkin (DG) method to solve hyperbolic equations involving δ-functions. In general, the numerical solutions are highly oscillatory near the singularities, which we refer to as the pollution region. We first analyze the size of the pollution region and the rate of convergence outside for some model equations, then apply the method to rendezvous algorithms and pressureless Euler equations to show the good performance of the DG method.

31. Ye, Xiu, University of Arkansas at Little Rock, xxye@ualr.edu

    Title: An introduction of new finite element methods: Weak Galerkin methods

    Abstract: Newly developed weak Galerkin finite element methods will be introduced for solving partial differential equations. Finite element methods can be classified as two big groups: conforming and nonconforming methods, (or roughly speaking: continuous and discontinuous methods). Constructions of conforming elements are not trivial in many situations. An alternative approach is to use discontinuous functions to approximate the true solutions of PDEs. However, for discontinuous functions, the strong derivatives are not well defined. The idea of weak Galerkin methods is to introduce well defined weak derivatives for discontinuous functions. As the results, the weak Galerkin finite element methods are general, flexible and parameter independent. Allowing the use of discontinuous approximating functions on arbitrary shape of polyhedra makes the weak Galerkin methods highly flexible in practical computation.

32. Ying, Wenjun, Shanghai Jiao Tong University, wying@sjtu.edu.cn

    Title: A kernel-free boundary integral method for Elliptic PDEs

    Abstract: In this talk, I will introduce a kernel-free boundary integral (KFBI) method for elliptic partial differential equations and presents its recent developments. The main idea of the KFBI method is to use a structured grid based solution to an equivalent interface problem to evaluate the boundary or volume integral(s) while the interface problem is solved by a fast elliptic solver. The KFBI method does not need to know the kernel of the integral operator or the Green's function of the elliptic operator. This makes the method a generalization of the standard boundary integral method for variable coefficient elliptic PDEs. I will also demonstrate the efficiency and accuracy of the KFBI method with numerical examples for problems in two and three space dimensions.

33. Zheng, Chunxiong, Tsinghua University, czheng@math.tsinghua.edu.cn

    Title: Global geometrical optics approximation to the high frequency Helmholtz equation in discontinuous medium

    Abstract: Global geometrical optics method is a new semi-classical approximation to the general linear wave equations in the short wavelength regime. In this talk, we apply this method to the Helmholtz equation in discontinuous medium. The key ingredient of this work is the deducing of amplitude relations on the interface which are necessary to form a globally valid asymptotic approximation to the wave field. Especially, the difficulty would arise when focal points happen to appear on the interface. We will explain how this problem can be solved.

34. Zhou, Haomin, Georgia Institute of Technology, hmzhou@math.gatech.edu

    Title: An Efficient Numerical Methods for Inverse Source Problems with Applications in Fluorescence Tomography

    Abstract:We present a new approach to solve the inverse source problem arising in Fluorescence Tomography (FT). In general, the solution is non-unique and the problem is severely ill- posed. It poses tremendous challenges in image reconstructions. In practice, the most widely used methods are based on Tikhonov-type regularizations, which minimize a cost function consisting of a regularization term and a data fitting term. We propose an alternative method, which overcomes the major difficulties, namely the non-uniqueness of the solution and noisy data fitting, in two separated steps. First we find a particular solution called orthogonal solution that satisfies the data fitting term. Then we add to it a correction function in the kernel space so that the final solution fulfills the regularization and other physical requirements, such as positivity. Moreover, there is no parameter needed to balance the data fitting and regularization terms. In addition, we use an efficient basis to represent the source function to form a hybrid strategy using spectral methods and finite element methods in the algorithm. The resulting algorithm can dramatically improve the computation speed over the existing methods.

And it is also robust against noise and can greatly improve the image resolutions. This is a joint work with Shui-Nee Chow (Math), Ke Yin (Math) and Ali Behrooz (ECE) from Georgia Tech.