Computational Analysis of Inverse Problems and Partial Differential Equations

Dedicated to Professors John Cannon and Zuhair Nashed

May 9--11, 2013
University of Central Florida
Orlando, Florida
Foreword

Dear Friends:

Welcome to the Conference on “Computational Analysis of Inverse Problems and Partial Differential Equations” (May 9—11, 2013) at the University of Central Florida, Orlando, Florida. This conference is dedicated to Professors John Canon and Zuhair Nashed on their 75th birthdays, and the main themes are inverse problems and partial differential equations, together with relevant computational analysis.

The organization committee would like to extend sincere thanks for your coming to the conference. We believe that the conference will be successful, and it will promote and enhance the collaborations/interactions among scholars from different areas, both geographically and mathematically. We also wish that the stay of the participants at Orlando will be very enjoyable!

We would like to express our acknowledgement to the following organizations/units for financial supports:

- National Science Foundation
- UCF Office of Research and Commercialization
- UCF College of Science
- UCF College of Engineering and Computer Science
- UCF Department of Mathematics

Conference Organization Committee
International Conference on
Computational Analysis of Inverse Problems
And Partial Differential Equations
May 9--11, 2013, University of Central Florida
Dedicated to Professors John Cannon and Zuhair Nashed

Thursday Morning (May 9, 2013)
Room: BA 0119

8:30—9:00  Registration
9:00—9:20  Opening
9:20—10:20  Heinz Engl (University of Vienna)

   How Zuhair Nashed influenced my work during the last 35 years

10:20—11:20  Paul DuChateau (Colorado State University)

   An appreciation of the contributions of John Cannon

11:20—12:30  Lunch Break
Thursday Afternoon (May 9, 2013)

Session A at BA 0119, Chaired by John Cannon

12:30—1:20  Ralph Showalter (Oregon State University)

Variational Problems & Mixed Formulations of coupled systems of mechanics and diffusion

1:20—2:10  Hong-ming Yin (Washington State University)

On American Option-Pricing Model with uncertain volatility

2:10—3:00  Yanping Lin (Hong Kong Polytechnic University)

Finite volume element methods: An overview on recent developments

3:00—3:20  Break

3:20—4:10  Salvador Perez-Esteva (Universidad Nacional Automa de Mexico)

Recovery of the singularities of the potential (live loads matrix) in the Navier equation of linear elasticity from the scattering amplitudes

4:10—5:00  Larry L. Schumaker (Vanderbilt University)

Spline Spaces and the FEM Method

5:00—5:50  Glenn F. Webb (Vanderbilt University)

The Ensemble Interpretation of Quantum Mechanics and the Two-Slit Experiment

6:30  Banquet at LiveOak on campus
Thursday Afternoon (May 9, 2013)

Session B at BA 0147, Chaired by Zuhair Nashed

12:30—1:20  Willi Freeden (University of Kaiserslautern)
             *From Fourier to Tykhonov: A Geomathematical Tour*

1:20—2:10  Chuck Groetsch (Citadel)
            *A One-dimensional Nonlinear Biological Inverse Problem*

2:10—3:00  O. Scherzer (University of Vienna)
            *Nonconvex Regularization*

3:00—3:20  **Break**

3:20—4:10  John Benedetto (University of Maryland)
            *Gabor systems: inverse problems and effective computation*

4:10—5:00  Robert Pertsch Gilbert (University of Delaware)
            *Acoustic Propagation in a Random Saturated Medium: The Biphasic Case*

5:00—5:50  Gilbert G. Walter (University of Milwaukee)
            *Prolate Spheroidal Wave Functions: Two Problems-One Solutions*

6:30  **Banquet at LiveOak on campus**
Friday Morning (May 10, 2013)

Session A at BA 0119, Chaired by Heinz Engl

8:30—9:20  Akram Aldroubi (Vanderbilt University)
            Subspace Segmentation: Problem, Nonlinear Approximations, and Applications to Motion Segmentation

9:20—10:10  Fadil Santosa (University of Minnesota)
            An inverse problem involving words

10:10—10:30  **Break**

10:30—11:20  H. T. Bank (NC State University)
            Mathematical and Statistical Modeling of Human Lymphocyte Proliferation Using CFSE Data

11:20—12:10  Edriss S. Titi (Weizmann Institute of Science and UC Irvine)
            Global Well-posedness of an Inviscid Three-dimensional Pseudo-Hasegawa-Mima-Charney-Obukhov Model

12:10—1:00  **Lunch Break, provided by Pearson Publishing**
Friday Morning (May 10, 2013)

Session B at BA 0147, Chaired by Paul DuChateau

8:30—9:20  Tao Lin (Virginia Tech)

Solving moving interface problems on Cartesian meshes

9:20—10:10  Zhuangyi Liu (University of Minnesota)

Stability and Regularity of an Abstract System of Coupled Hyperbolic and Parabolic Equations

10:10—10:30  Break

10:30—11:20  Xiangsheng Xu (Mississippi State University)

Existence theory for a class of semiconductor model

11:20—12:10  Mourad E. H. Ismail (University of Central Florida)

Landau Constants

12:10—1:00  Lunch Break, provided by Pearson Publishing
Friday Afternoon (May 10, 2013)
Session A at BA 0119, Chaired by Willi Freeden

1:00—1:50  Ali H. M. Murid (Universiti Teknologi Malaysia)
   Numerical Conformal Mapping and its Inverse of Unbounded Multiply Connected Regions onto Logarithmic Spiral Slit Regions and Rectilinear Slit Regions

1:50—2:40  John A. Burns (Virginia Tech)
   Parabolic Boundary Control Problems with Delayed Actuator Dynamics: Well-Posedness & Approximation

2:40—3:10  Haichao Wang (University of California, Davis)
   Compressive MIMO Radar with Random Sensor Arrays

3:10—3:30  Break

3:30—4:20  Radu Balan (University of Maryland)
   Robustness and Stability of Reconstruction from Magnitudes of Frame Coefficients

4:20—5:10  Alfred Carasso (National Institute of Standards and Technology)
   Unexpected success and surprising failure in backward in time continuation in linear and nonlinear parabolic equations and their applications

5:10—5:40  Gunay Dogan (National Institute of Standards and Technology)
   Shape reconstruction in computed tomography

5:40—6:10  Xuemei Chen (University of Maryland)
   A null space property approach to compressed sensing with frames

6:10—6:40  Jacqueline Teresa Davis (Vanderbilt University)
   Dynamical sampling in $l^2(Z)$ and shift-invariant spaces
Friday Afternoon (May 10, 2013)
Session B at BA 0147, Chaired by Ralph Showalter

1:00—1:50  Bei Hu (University of Notre Dame)
  
  *PDE tumor models*

1:50—2:40  Giles Auchmuty (University of Houston)
  
  *Steklov Eigenfunctions and the Representation of Solutions of Linear Elliptic Problems*

2:40—3:10  Gaik Ambartsoumian (University of Texas at Arlington)
  
  *Injectivity and Inversion of Ultrasound Operators in the Spherical Geometry*

3:10—3:30  Break

3:30—4:20  Fangshan Liu (Delaware State University)
  
  *On electromagnetic transmission eigenvalues*

4:20—5:10  Yu-wen Wang (Harbin Institute of Petroleum, China)
  
  *Generalized Green Functions and Ill-Posed Quasilinear Two-Point Neumann Boundary Value problems*

5:10—5:40  Naian Liao (Vanderbilt University)
  
  *Recent Processes on Local Behaviors of a Logarithmic Diffusion Equation*

5:40—6:10  Qing Yang (Shangdong Normal University and Virginia Tech)
  
  *An Approximation of Transient Behavior of Semiconductor Devices by Mixed Finite Element Method and Characteristics-mixed Finite Element Method*

6:10—6:40  Zhisheng Shuai (University of Central Florida)
  
  *Global Dynamical Analysis of an Age-Structured Cholera Model*
Saturday Morning (May 11, 2013)
Session A at BA 0119, Chaired by Gilbert G. Walter

8:30—9:20  Cornelis van der Mee (Universita di Cagliari)
            
            Integrale Nonlinear Evolution Equations: Solution by Inverse Scattering Transform

9:20—9:50  Abdullah Said Erdogan (Fatih University, Turkey)
            
            On the inverse problem of determining a space dependent source in one-dimensional heat equation

9:50—10:20  Amir Moradifam (Columbia University)
            
            Conductivity imaging from one interior measurement and weighted least gradient problems

10:20—10:40  Break

10:40—11:10  Roman Andreev (University of Maryland)
            
            Sparse space-time Petrov-Galerkin discretizations for parabolic evolution equation

11:10—11:40  V. D. Sharma (Indian Institute of Technology, India)
            
            Interaction of a C1 wave with elementary waves of the Riemann problem for Euler equations of gasdynamics

11:40—12:30  Paul Eggermont (University of Delaware)
            
            Regularization parameter selection for ill-posed problems with weakly bounded noise
Saturday Morning (May 11, 2013)
Session B at BA 0147, Chaired by Hong-ming Yin

8:30—9:20 Ahmed I. Zayed (Depaul University)

*Chromatic Expansions in Function Spaces*

9:20—9:50 Trung Thanh Nyuyen (University of North Carolina at Charlotte)

*Reconstruction of refractive index from experimental back-scattering data using a globally convergent method*

9:50—10:20 Fang Zeng (Delaware State University)

*An inverse electromagnetic scattering problem for cavity*

10:20—10:40 Break

10:40—11:10 Daniel J. Galiffa (Penn State Erie)

*Recent Developments of Nonlocal Models in Thermodynamics and Epidemiology*

11:10—11:40 Kamran Sadiq (University of Central Florida)

*On the range of the attenuated Radon transform in convex sets*

11:40—12:30 Volker Michel (University of Siegen)

*A Sparse Regularization Method for Ill-posed Inverse Problems in Geophysics and Geodesy*
Subspace Segmentation: Problem, Nonlinear Approximations, and Applications to Motion Segmentation

Abstract: The subspace segmentation problem is fundamental in many applications. The goal is to cluster data drawn from an unknown union of subspaces. In this talk we state the problem and describe its connection to other areas of mathematics and engineering. We then review the mathematical and algorithmic methods created to solve this problem and some of its particular cases. We also describe the problem of motion tracking in videos and its connection to the subspace segmentation problem and compare the various techniques for solving it.

Injectivity and Inversion of Ultrasound Operators in the Spherical Geometry

Abstract: In ultrasound tomography an emitter sends acoustic waves through the body, and the reflections of these waves are registered by a receiver. These data measured for various locations of emitter and receiver are then used to reconstruct the acoustic reflectivity function, which represents an image of the interior of the body. Mathematically this procedure is equivalent to the inversion of an operator, which puts into correspondence to the image function, the measured reflections at available receiver locations. The talk discusses the injectivity of ultrasound operators in the spherical geometry of data acquisition, and exact inversion procedures derived for several setups in this geometry.

Sparse space-time Petrov-Galerkin discretizations for parabolic evolution equations

Abstract: In view of applications in e.g. optimal control problems with parabolic PDE constraints and massively parallel computations of time-dependent problems, space-time compressive discretizations of parabolic evolution equations are of increasing interest. In this talk we discuss space-time (sparse) tensor product simultaneous Petrov-Galerkin discretizations of parabolic evolution equations, and propose efficient preconditioners for the iterative solution of the resulting single linear system of equations. Therein, space-time stability of the discretization, i.e., the validity of the discrete inf-sup condition with respect to suitable space-time norms uniformly in the discretization parameters, is essential. Viewing the Crank-Nicolson time-stepping scheme as a space-time Petrov-Galerkin discretization, we show that it is conditionally space-time stable. This motivates a general minimal residual Petrov-Galerkin discretization framework along with
space-time stable families of trial and test spaces of (sparse) tensor product type, resulting in space-time compressive discretization algorithms.

References


Giles Auchmuty (giles@math.uh.edu) – University of Houston

Steklov Eigenfunctions and the Representation of Solutions of Linear Elliptic Problems

Abstract: This talk will describe results about the dependence of solutions of homogeneous linear self-adjoint second-order elliptic boundary value problems $Lu = 0$ on the boundary condition $Bu = g$. The boundary data may be Dirichlet, Robin, Neumann or of mixed type. The Steklov eigenproblem for the operator $L$ will be described and used to describe an orthogonal basis for the null space $N(L) \subset H^1(\Omega)$. This construction provides a characterization, and spectral representation, of the trace spaces $H^s(\partial \Omega)$ valid for when $\partial \Omega$ is Lipschitz - and even slightly weaker conditions. These results enable spectral representations of the solutions of boundary value problems for the homogeneous equation on these regions. That is, they provide spectral representations of various boundary integral operators and generalized Poisson kernels.

When $\Omega$ is an exterior region in $\mathbb{R}^N$ with $N \geq 3$, the appropriate space for solutions of Poisson type equations is no longer $H^1(\Omega)$ - as the solutions need not be in $L^2(\Omega)$. The space of finite energy functions on such regions $\Omega$ will be described and representations of solutions on the region will be found. These representations generalize the theory of multipole expansions for classical electrostatic and gravitational field theories.

Radu Balan (rvbalan@math.umd.edu) – Department of Mathematics, University of Maryland

Robustness and Stability of Reconstruction from Magnitudes of Frame Coefficients

Abstract: This paper is concerned with the question of reconstructing a vector in a finite-dimensional real Hilbert space when only the magnitudes of the coefficients of the vector under a redundant linear map are known. We analyze various Lipschitz bounds of the nonlinear analysis map and we establish theoretical performance bounds of any reconstruction algorithm.

This is joint work with Yang Wang.

H.T. Banks (htbanks@nmsu.edu) – Center for Research in Scientific Computation, Center for Quantitative Sciences in Biomedicine, N. C. State University

Mathematical and Statistical Modeling of Human Lymphocyte Proliferation Using CFSE Data

Abstract: CFSE analysis of proliferating cell populations is a tool of growing popularity for the study of cell division and division-linked changes in cell behavior. Partial differential equation (PDE) models are
presented to describe lymphocyte dynamics in a CFSE proliferation assay. Previously poorly understood physical mechanisms accounting for dye dilution by division, auto fluorescence and label decay are included. A new class of division-dependent compartmental models allows one to separate proliferation and death rates from intracellular label dynamics. By fitting the new models to the commonly used histogram representation of the data, it is shown that these improvements result in models with a strong physical basis which are still fully capable of replicating the behavior observed in in vitro data. Some mathematical and statistical aspects of the corresponding inverse problems are discussed. The new models provide quantitative techniques that are useful for the comparison of CFSE proliferation assay data across different data sets and experimental conditions. Variability and uncertainty in data and modeling are discussed. The efforts involve joint investigations with W. C. Thompson and a team of immunologists in Barcelona led by A. Meyerhans.

John Benedetto (jjb@math.umd.edu) – University of Maryland  
Thursday 3:20pm BA147

Gabor systems: inverse problems and effective computation

Abstract: There are three topics. In the first, finite Gabor frame matrices are designed by means of number theoretic sequences with optimal ambiguity function behavior in order to solve matrix equations with sparse solutions and by means of orthogonal matching pursuit. The number theory is joint work with Robert Benedetto and Joseph Woodworth. In the second, cases of the HRT conjecture for finite linear combinations of Gabor atoms on $\mathbb{R}$ are solved by means of Kronecker’s theorem and Tauberian theory. This is joint work with Abdel Bourouihiya of NOVA. In the third, Beurlings notion of balayage is used to solve sampling problems associated with pseudo-differential operators. This is joint work with Enrico AuYeung.

John A. Burns (jaburns@vt.edu) – Interdisciplinary Center for Applied Mathematics, Blacksburg, VA 24061  
Friday 1:50pm BA119

Parabolic Boundary Control Problems with Delayed Actuator Dynamics: Well-Posedness & Approximation

Abstract: In this paper we consider a control problem for the convection diffusion equation and investigate the impact of including actuator dynamics and delays. The problem is motivated by applications to control of energy efficient buildings where actuation is provided by a HVAC system. The basic model is governed by a partial differential equation which is augmented to include a model of an actuator with delays. The basic system is described by the partial differential equation

$$\frac{\partial}{\partial t} \theta(t, x) = c^2 \nabla^2 \theta(t, x) + [\kappa(x) \cdot \nabla \theta(t, x)] + \int_\Omega g(x, y)w(t, y)dy, \quad x \in \Omega \subset \mathbb{R}^p$$

with input $u_\theta(\cdot)$ at the boundary

$$\theta(t, x)|_{\partial \Omega} = b(x)u_\theta(t).$$

Here, $\int_\Omega g(x, y)w(t, y)dy$ represents a spatially averaged disturbance. In addition, we assume that the input $u_\theta(t)$ is the output of a dynamical system governed by a delay system so that

$$u_\theta(t) = Hz(t),$$

where

$$\dot{z}(t) = A_0z(t) + A_1z(t-r) + Bu(t)$$

and $u(\cdot)$ is the control input to the actuator. Thus, the system with actuator dynamics has the form

$$\frac{\partial}{\partial t} \theta(t, x) = c^2 \nabla^2 \theta(t, x) + [\kappa(x) \cdot \nabla \theta(t, x)] + \int_\Omega g(x, y)w(t, y)dy, \quad x \in \Omega \subset \mathbb{R}^p$$

(1)

$$\dot{z}(t) = A_0z(t) + A_1z(t-r) + Bu(t)$$
with boundary condition

\[ \theta(t, x)|_{\partial \Omega} = b(x) H z(t). \]

We show that under suitable conditions, the coupled system (1) - (2) is well posed in a standard Hilbert space and we use this corresponding abstract formulation to construct numerical methods for control design. We apply these results to a simple 1D boundary control system to illustrate the ideas and numerical methods.

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**Alfred Carasso** (alfred.carasso@nist.gov) – National Institute of Standards and Technology  
Friday 4:20pm BA119

*Unexpected success and surprising failure in backward in time continuation in linear and nonlinear parabolic equations and their applications*

**Abstract:** Backward in time continuation in linear autonomous self adjoint parabolic equations has found useful application. One active research area lies in image deblurring, where time-reversed fractional and logarithmic diffusion equations are surprisingly effective in blind deconvolution of such valuable scientific imagery as nanoscale scanning electron micrographs, MRI and PET brain scans, and astronomical galaxy images. Such parabolic pseudo differential equations originate from randomization of Brownian motion via Bochner subordination, and are related to heavy-tailed point spread functions as opposed to the more familiar Gaussian point spread functions. How the imaging process in these successful applications leads to such exotic pdes, is not fully understood.

In contrast, backward continuation in nonlinear parabolic equations can be treacherous. An iterative procedure is developed that can be used to explore the deblurring of images blurred by nonlinear second order parabolic equations. Instructive examples are given, illustrating the unexpected influence of certain types of nonlinearities. Visually and statistically indistinguishable blurred images are presented that result in vastly different deblurring results. Evidently, how an image is nonlinearly blurred is critical, in addition to the amount of blur. Also, previously useful blind deconvolution techniques generally fail on nonlinearly blurred images, even when such images display Fourier space behavior that is very similar to successfully processed linearly blurred images.

Finally, well-established smoothness and positivity constraints may be ineffective in regularizing backward in time continuation in linear or nonlinear parabolic equations, if such equations deviate too strongly from the linear autonomous self adjoint canonical model. Examples of smooth, non negative, physically plausible, yet false reconstructions, have been found.

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**Xuemei Chen** (xuemeic@math.umd.edu) – Norbert Wiener Center, Department of Mathematics, University of Maryland, College Park  
Friday 5:40pm BA119

*A null space property approach to compressed sensing with frames*

**Abstract:** An interesting topic in compressive sensing concerns problems of sensing and recovering signals with sparse representations in a dictionary. In this note, we study conditions of sensing matrices \( A \) for the \( \ell^1 \)-synthesis method to accurately recover sparse, or nearly sparse signals in a given dictionary \( D \). In particular, we propose a dictionary based null space property (D-NSP) which, to the best of our knowledge, is the first sufficient and necessary condition for the success of the \( \ell^1 \) recovery. This new property is then utilized to detect some of those dictionaries whose sparse families cannot be compressed universally. Moreover, when the dictionary is full spark, we show that \( AD \) being NSP, which is well-known to be only sufficient for stable recovery via \( \ell^1 \)-synthesis method, is indeed necessary as well. This is a joint work with Haichao Wang and Rongrong Wang.
Jacqueline Teresa Davis (jacqueline.t.davis@Vanderbilt.Edu) – Department of Mathematics, Vanderbilt University  

**Dynamical sampling in $\ell^2(\mathbb{Z})$ and shift-invariant spaces**

**Abstract:** We propose a new type of inverse problem that arises from sampling an evolving field at various times. We show that coarse samplings taken at varying times often contain the same information as a finer sampling taken at the earliest time. In other words, under some conditions on the evolving system, we can trade time samples for spatial samples.

The talk will begin by considering the recovery of a signal $x \in \ell^2(\mathbb{Z})$ in a dynamical system with evolution rule given by the operator $A : \ell^2(\mathbb{Z}) \to \ell^2(\mathbb{Z})$, where $Ax = a * x$ for some $a \in \ell^1(\mathbb{Z})$. In other words, the signal at time $t = n$ is given by $A^n x = (a * \cdots * a)_n * x$. Undersampling the original signal by a rate $m$ can be offset by $m - 1$ additional time samples and a few extra samples of the original signal. This is joint work with Akram Aldroubi and Ilya Krishtal.

The results for $\ell^2(\mathbb{Z})$ can only sometimes be extended to dynamical sampling in a shift-invariant space. We look specifically at when and how the dynamical sampling problem in a shift-invariant space can be reduced to the problem in $\ell^2(\mathbb{Z})$. This portion is joint work with Roza Aceska, Akram Aldroubi, and Armenak Petrosyan.

Gunay Dogan (gunay.dogan@nist.gov) – Theiss Research, National Institute of Standards of Technology  

**Shape reconstruction in computed tomography**

**Abstract:** Computed tomography (CT) is essential to modern medicine. Usually practitioners’ interest in CT is to identify and quantify structures found in CT images. Traditionally, this is done by post-processing of reconstructed images (i.e. segmenting the images). In this talk, we propose to address this problem directly; we extract the geometric structures directly from measured data, bypassing the reconstruction phase. We formulate this task as a shape optimization problem and devise an efficient numerical algorithm to perform the optimization.

Paul DuChateau (duchateau.paul@gmail.com) – Colorado State University  

**An appreciation of the contributions of John Cannon**

**Abstract:** John Cannon has contributed to many areas of mathematics during his career but I have been most involved with his work in inverse problems. He began working in this area at the very beginning when we not only didn’t know the answers to many questions, we didn’t even know what were the right questions. Since there were no guidelines or precedents to follow, John invented several novel and clever approaches for inverse problems including the “intersecting graphs method” and “trace-type functionals”. His often unconventional ways of attacking problems influenced my own ideas to a great extent and I will illustrate what I think is a very ”Cannon-like” technique for treating a class of inverse problems.
Paul Eggermont (eggermon@UDel.Edu) – Applied Economics and Statistics, University of Delaware  

Saturday 11:40am  BA119

Regularization parameter selection for ill-posed problems with weakly bounded noise

Abstract: We investigate regularization parameter selection for ill-posed problems with weakly bounded noise. Besides Lepskii’s principle, we discuss a weak discrepancy principle as well as the analogues of Wahba’s generalized cross validation (GCV) and generalized maximum likelihood (GML) procedures for random noise. We point out the crucial differences between these two strategies and show some simulation results illustrating the effectiveness of these methods even when they “work”.

Heinz Engl (heinz.engl@univie.ac.at) – University of Vienna, Austria  

Thursday 9:20am  BA119

How Zuhair Nashed influenced my work during the last 35 years

Abstract: I first met Prof. Nashed during my stay at Georgia Tech in 1976 and was invited by him to Delaware, where I stayed 1978/79. During that time, we work together on random operator equations. Also, we did work on extremal characterizations of various generalized inverses. Both topics were taken by (with different coauthors) decades later in connection with inverse problems, a field to which I was introduced by Zuhair during my stay in Delaware and especially at his very influential 1979 conference on that topic. In the talk, I will survey some results about the functional analytic theory of nonlinear inverse problems and also mention recent work on inverse problems in systems biology. I am convinced (and will try to show this) that my view of applied mathematics and also my style of writing about mathematics were hugely influenced by Zuhair.

Abdullah Said Erdogan (Abdullah.Erdogan@ucf.edu) – Fatih University, Department of Mathematics, Istanbul, Turkey  

Saturday 9:20am  BA119

On the inverse problem of determining a space dependent source in one-dimensional heat equation

Abstract: Computational analysis of blood flow inside capillary vascular system has been investigated by many researchers including project team members. Generally, the flow occurs by the pressure difference between two ends. This pressure difference may vary depending on time and/or radius inside the vessels. In this case, the model is defined by diffusion equation which consists two unknown functions. Additional information about the solution is provided throughout some part of the domain. In this paper, construction of a stable numerical method for the approximate solution of the problem is aimed. Theoretical statements are presented and are supported by the results of a numerical example. This work is supported by the Scientific Research Fund of Fatih University under the project number P50041201B. The paper is based on a joint work with Prof. Allaberen Ashyralyev (Fatih University, Turkey) and Ali Ugur Sazaklioglu (Fatih University, Turkey).
Willi Freeden (freeden@mathematik.uni-kl.de) – University of Kaiserslautern, Germany  Thursday 12:30pm  BA147

From Fourier to Tykhonov: A Geomathematical Tour

Abstract: First the basic ideas of selective multiscale reconstruction of functions on the sphere from error-affected data is outlined under the canonical premise that multiscale approximation can be well represented in terms of a relatively small number of expansion coefficients at various resolution levels. A tree algorithm is presented to efficiently remove the noise at different scales using a priori statistical information.

Second the derived concepts are used in inverse problems of geophysical relevance, for example, downward continuation problems of today’s satellite technology.

Daniel J. Galiffa (djg34@psu.edu) – Department of Mathematics, Penn State Erie, The Behrend College  Saturday 10:40am  BA147

Recent Developments of Nonlocal Models in Thermodynamics and Epidemiology

Abstract: In this talk, we give an overview of the several joint works of J.R. Cannon and D.J. Galiffa. Specifically, we address how the nonlocal structure $\alpha \left( \int_{\Omega} u(x) dx \right)$ has played an important role in the development and analysis of mathematical models in thermodynamics (thermodynamic equilibrium via Coulomb potential) and epidemiology (insect borne diseases). We will also cover the finite-difference methods utilized to approximate the analytic solutions of these models and supplement these with examples of the corresponding numerical simulations. We conclude the talk by discussing the construction of new models that arise from the aforementioned ones, which have applications to both epidemics and pandemics.

Robert Pertsch Gilbert (gilbert@math.udel.edu) – University of Delaware Thursday 4:10pm  BA147

Acoustic Propagation in a Random Saturated Medium: The Biphasic Case

Abstract: This paper is a continuation of our study of the effective acoustic behavior of porous media with microstructure. While in our previous works we considered the monophasic case (for both periodic and random geometry) [6, 7, 8, 9], here we focus on the situation when fluid and solid move out of phase. This is the case when the ratio of elasticity coefficients to viscosity coefficients is of order $\varepsilon^2$ and it corresponds to the dilatational wave of the second kind or the fast wave predicted by Biot theory [1]. We study the problem of derivation of an effective model of acoustic wave propagation in a two-phase, non-periodic medium modeling a fine mixture of linear elastic solid and a viscous Newtonian fluid. Bone tissue is an important example of a composite material that can be modeled in this fashion. We extend known homogenization results for periodic geometries to the case a stationary random, scale-separated microstructure. The ratio $\varepsilon$ of the macroscopic length scale and a typical size of the microstructural inhomogeneity is a small parameter of the problem. We employ stochastic two-scale convergence in the mean to pass to the limit $\varepsilon \to 0$ in the governing equations. The effective model is a biphasic phase viscoelastic material with long time history dependence. In this paper, as in our recent work [8], we assume that an elastic medium is randomly fissured with the associated random field being statistically homogeneous, with built-in scale separation. The effective equations are derived using the stochastic two-scale convergence in the mean [4, 10, 3]. Elimination of the corrector displacements is explained in detail for the periodic geometry. Considering periodic geometry is not a restriction since the periodic approximation procedure in the limit produces the same effective properties.
as the stochastic homogenization as showed by Bourgeat and Piatnitski [2] (see also Byström et al. [5] for some numerical examples). The effective equations model a biphasic macroscopic behavior with long-time history dependence.

This is a joint work with Alexander Panchenko (Washington State University) and Ana Vasilic (United Arab Emirates University).

References


Chuck Groetsch (groetschc1@citadel.edu) – The Citadel

A One-dimensional Nonlinear Biological Inverse Problem

Abstract: In an experimental procedure developed by S. Kleene, an olfactory celium is detached at its base and drawn into a recording pipette. The open celium base is then immersed in a bath of a channel activating agent (cAMP) which diffuses into the celium interior, opening channels as it goes, and initiating a trans-membrane current. The total current is recorded as a function of time and serves as data for a nonlinear integral equation of the first kind modeling the spatial distribution of ion channels along the length of the celium. We discuss this model as a tool for assessing the spatial distribution of ion channels. A linear Fredholm integral equation of the first kind that results from simplifications of this model is treated and a numerical procedure is proposed for a class of integral equations suggested by this simplified model. Numerical results using simulated and laboratory data are presented.

Bei Hu (b1hu@nd.edu) – Department of Applied Computational Mathematics and Statistics, University of Notre Dame

PDE tumor models

Abstract: We shall discuss the recent progress (joint work with many others) on the PDE tumor models, the bifurcation diagram near the bifurcation point, the bifurcation diagram extensions and the intersection of bifurcation diagram for different bifurcation branch, and the numerical implementation, numerical simulation, special homotopy techniques, special numerical (multiple) solutions.
Landau Constants

Abstract: We derive inequalities and a complete asymptotic expansion for the Landau constants $G_n$, as $n \to \infty$ using the asymptotic sequence $n!/(n+k)!$. We also introduce a $q$-analogue of the Landau constants and calculate their large degree asymptotics.

This talk is based on a joint work with Xin Li.

Naian Liao (naian.liao@vanderbilt.edu) – Math Department, Vanderbilt University  
Friday 5:10pm  BA147

Recent Processes on Local Behaviors of a Logarithmic Diffusion Equation

Abstract: In this talk, I will explain some recent progresses on the local behavior of the equation $u_t = \Delta \ln u$ including a Harnack-type inequality, $L^1$ form Harnack inequality and local special analyticity. I will also show you their connection with the porous medium equation $u_t = \Delta (u^m/m)$ and all estimates are stable as $m$ tends to 0.

Tao Lin (tlin@vt.edu) – Department of Mathematics, Virginia Tech  
Friday 8:30am  BA147

Solving moving interface problems on Cartesian meshes

Abstract: In engineering and sciences, many simulations need to be carried out over domains consisting of multiple homogeneous materials separated from each other by curves/surfaces. This often leads to the so-called interface problems of partial differential equations whose coefficients are piecewise constants. Traditional finite element methods can be used to solve interface problems satisfactorily with meshes constructed according to the material interfaces; otherwise, convergence cannot be guaranteed. This requires each element in a mesh to be occupied essentially by one of the materials. In other words, each element needs to be on one side of a material interface. Therefore, the mesh in a traditional finite element method for solving an interface problem has to be unstructured to handle non-trivial interface configurations. This restriction usually causes numerous negative impacts on the simulations with moving material interfaces. In this talk, we will discuss how the recently developed immersed finite elements (IFE) can alleviate this limitation of traditional finite element methods. We will present a group of IFE methods for solving parabolic equations whose diffusion coefficient is discontinuous across a time dependent interface. These methods can use a fixed structured mesh because IFEs can handle interface jump conditions without requiring the mesh to be aligned with the interface. Numerical examples will be provided to demonstrate features of these IFE methods.

Yanping Lin (yanlin@ualberta.ca) – Department of Applied Mathematics, Hong Kong Polytechnic University  
Thursday 2:10pm  BA119

Finite volume element methods: An overview on recent developments
Abstract: In this talk, we present an overview of the progress of the finite volume element (FVE) methods. We show that the linear FVE methods are quite mature due to their close relation to the linear finite element methods, while development of higher order finite volume methods remains a difficult and promising research front. Theoretical analysis, as well as the algorithms and applications of these methods, are reviewed.

T. Turner, J. Sun and Fengshan Liu* (fLiu@desu.edu) – Department of Mathematical Sciences, Applied Mathematics Research Center, Delaware State University

Abstract: The electromagnetic interior transmission problem is a boundary value problem which is neither elliptic nor self-adjoint. The associated transmission eigenvalue problem has important applications in the inverse electromagnetic scattering theory for inhomogeneous media. In this talk, we show that in general there do not exist purely imaginary electromagnetic transmission eigenvalues. For constant index of refraction, we prove that it is uniquely determined by the smallest (real) transmission eigenvalue. Finally, we show that complex transmission eigenvalues must lie in a certain region in the complex plane. The result is verified by examples.

Zhuangyi Liu (zliu@d.umn.edu) – Department of Mathematics and Statistics, University of Minnesota, Duluth, MN 55812

Abstract: In this talk, for parameters \((\alpha,\beta) \in S = [0,1] \times [0,1]\), we consider an abstract system of coupled hyperbolic and parabolic equations

\[
\begin{align*}
    u_{tt} &= -Au + \gamma A^\alpha \theta, \\
    \theta_t &= -\gamma A^\alpha u_t - k A^\beta \theta, \\
    u(0) &= u_0, \quad u_t(0) = v_0, \quad \theta(0) = \theta_0
\end{align*}
\]

where \(A\) is a self-adjoint, positive definite operator on a Hilbert space \(H\), with eigenvalues \(\lambda_n \to \infty\) as \(n \to \infty\).

We will give a complete stability analysis and regularity analysis for (3). Indeed, the unit square \(S\) can be divided into stability sub-regions where (3) is exponentially stable, polynomially stable, and unstable, respectively. On the other hand, the unit square \(S\) can also be divided into regularity sub-regions where the semigroup (3) is analytic, of Gevrey class, and non-smooth, respectively.

Volker Michel (michel@mathematik.uni-siegen.de) – Geomathematics Group, University of Siegen, Germany

Abstract: The UNESCO year Mathematics of Planet Earth 2013 is dedicated to mathematical progress that helps us to gain a better understanding of the system Earth. Accurate models of the Earth are required to comprehend phenomena like the climate change. Such models of the Earths interior and surface require the resolution of several ill-posed inverse problems. Due to the complexity of the Earth and the huge amount of available data, sparsity techniques are necessary to handle the corresponding problems.
In this talk, we show how a greedy algorithm can be modified such that it can be applied to problems with two new aspects: ill-posed inverse problems and spherical domains. The novel algorithm is able to reconstruct solutions in a stable way and it combines trial functions of very different kinds. It turns out that the algorithm is able to locally adapt the resolution of the result in particular, with respect to the detail structure of the solution. Theoretical and numerical results are shown.

Amir Moradifam (am3937@columbia.edu) – Columbia University

Conductivity imaging from one interior measurement and weighted least gradient problems

Abstract: I will discuss the problem of recovering an isotropic conductivity outside some perfectly conducting or insulating inclusions from knowledge of the magnitude of one current density vector field. This problem is closely related to uniqueness of minimizers of certain weighted least gradient problems and theory of minimal surfaces. We prove that the conductivity outside of the inclusions as well as the shape and position of the inclusions are uniquely determined by the magnitude of the current generated by imposing a given boundary voltage. I will also present a convergent algorithm for the problem and show some numerical experiments.

Ali H. M. Murid (alihassan@utm.my) – Department of Mathematical Sciences, Faculty of Science, Universiti Teknologi Malaysia and UTM Centre of Industrial and Applied Mathematics, Universiti Teknologi Malaysia

Numerical Conformal Mapping and its Inverse of Unbounded Multiply Connected Regions onto Logarithmic Spiral Slit Regions and Rectilinear Slit Regions

Abstract: This paper presents a boundary integral equation method with the adjoint generalized Neumann kernel for computing conformal mapping of unbounded multiply connected regions and its inverse onto several classes of canonical regions. For each canonical region, two integral equations are solved before one can approximate the boundary values of the mapping function. Cauchy’s type integrals are used for computing the mapping function and its inverse for interior points. This method also works for regions with piecewise smooth boundaries. Some examples are given to illustrate the effectiveness of the proposed method.

This is a joint work with Arif A.M. Yunus (Faculty of Science and Technology, Universiti Sains Islam Malaysia, 71800, Bandar Baru Nilai, Negeri Sembilan, Malaysia) and Mohamed M. S. Nasser (Department of Mathematics, Faculty of Science, King Khalid University, P. O. Box 9004, Abha, Saudi Arabia).

Trung Thanh Nguyen (tnguy152@uncc.edu) – University of North Carolina at Charlotte

Reconstruction of refractive index from experimental back-scattering data using a globally convergent method

Abstract: Consider the wave equation

\[ \epsilon^2(x)u_{tt}(x,t) - \Delta u(x,t) = 0, \quad x \in \mathbb{R}^3, \quad t \in (0, \infty) \]

with the initial conditions

\[ u(x,0) = 0, \quad u_t(x,0) = \delta(x - x_0), \quad x \in \mathbb{R}^3. \]
In electromagnetic wave propagation theory, the coefficient $\epsilon$ represents the refractive index of the medium in which the wave propagates. Assume that the $\epsilon(x) \in [1, 1 + d]$ with some positive constant $d$. Moreover, $\epsilon(x) = 1$ outside a bounded domain $\Omega \subset \mathbb{R}^3$ and $x_0 \notin \Omega$.

The inverse problem to be considered in this talk is to reconstruct the refractive index $\epsilon(x), x \in \Omega$ using one boundary measurement

\[ u(x, t) = g(x, t), (x, t) \in \Gamma \times (0, \infty), \]

where $\Gamma$ is the part of the boundary $\partial \Omega$ corresponding to the back scattering of the incident wave by the inhomogeneous medium.

In this talk, we discuss challenges of using experimental data in this inverse problem. We show a huge misfit between experimental data and simulated one and present data processing steps for converting the former to an approximate of the latter. We also show reconstruction results obtained by a globally convergent method (for this method, see L. Beilina & M. Klibanov Approximate Global Convergence and Adaptivity for Coefficient Inverse Problems, Springer, 2012).

This is a joint work with Larisa Beilina (Chalmers University of Technology and Gothenburg University, Sweden), Michael V. Klibanov and Michael A. Fiddy (University of North Carolina at Charlotte).

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**Salvador Pérez-Esteva** (spesteva@im.unam.mx) – Instituto de Matematicas Unidad Cuernavaca Universidad Nacional Autonoma de Mexico

*Thursday 3:20pm BA119*

**Recovery of the singularities of the potential (live loads matrix) in the Navier equation of linear elasticity from the scattering amplitudes**

**Abstract:** We consider the Navier equation of elasticity with live loads

\[ \Delta^* u + \omega^2 u = Q(x)u \]

where $\Delta^* u = \mu \Delta u + (\lambda + \mu) \nabla \text{div} u$. For a nonsmooth $Q(x)$ with compact support, we construct solutions of the form

\[ u = u_i + v, \]

where $u_i$ is an incident plane wave and the function $v$, called a scattering solution, satisfies Kumpradze radiation condition. From the scattering amplitudes (the far-field-patterns) of scattering solutions, we construct a Born approximation to recover the main singularities of $Q$ in the scale of the Sobolev spaces.

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**Kamran Sadiq** and **Alexandru Tamasan** (ksadiq@knights.ucf.edu) – Department of Mathematics, University of Central Florida

*Saturday 11:10am BA147*

**ON THE RANGE OF THE ATTENUATED RADON TRANSFORM IN CONVEX SETS**

**Abstract:** We present some new necessary and sufficient conditions for a function on $\partial \Omega \times S^1$ to represent the attenuated Radon transform of a sufficiently smooth function with support in a convex set $\bar{\Omega} \subset \mathbb{R}^2$. While the well-known Cavalieri (moment) conditions represent constraints on the angular variable, our conditions express constraints on the boundary of the domain. The approach is based on an explicit Hilbert transform associated with traces of the boundary of $A$-analytic functions in the sense of Bukhgeim.

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**Fadil Santosa** (santosa@ima.umn.edu) – Institute for Mathematics and its Applications, and the School of Mathematics, University of Minnesota

*Friday 9:20am BA119*
An inverse problem involving words

Abstract: The speaker will describe an inverse problem for words. By words, we mean a short sequence of ASCII characters. Such inverse problems arise, for example, in bar code decoding. The measured signal could be data from a laser-based scanner or an image from a camera-based device. The desired unknown is not a function (continuous parameters) representing the bar code, but the ASCII characters (discrete variables) encoded in the bar code. The presentation will go over the modeling and the formulation of the inverse problem. Theoretical issues such as reconstruction and stability, along with algorithms for decoding, will be presented.

V. D. Sharma (vsharma@iitb.ac.in) – Department of Mathematics, Indian Institute of Technology, Bombay, India

Saturday 11:10am BA119

Interaction of a $C^1$ wave with elementary waves of the Riemann problem for Euler equations of gasdynamics

Abstract: We study the interaction of a weak discontinuity wave with the elementary waves of the Riemann problem for the one-dimensional Euler equations governing the flow of ideal polytropic gases, and investigate the effects of initial states and the shock strength on the jumps in shock acceleration, and the reflected and transmitted waves. The system of transport equations for $C^1$ discontinuities turns out to be a Bernoulli system when eigenvalues are simple. The attention is focused on the study of the interaction between $C^1$ discontinuities and the elementary wave solutions (shocks and characteristic shocks) of the Riemann problem for the Euler equations, and for that sake, we first solve the Riemann problem and then consider the interaction of the wave pattern that finally develops. The test-data are considered for the three Riemann problems to analyze the situation when the initial discontinuity breaks up into two shocks and a characteristic shock. Given the state on one side of the discontinuity and varying the state on the other, the intermediate states are determined as solutions to the Riemann problem. It is investigated as to how a change in the initial data influences the solution of the Riemann problem; it is found that if the initial $C^1$ wave is an expansion wave then it will always impinge on the shock after a finite time, however a compression wave can meet the shock only under certain conditions. Further, an increase in the shock strength causes the amplitudes of the transmitted and reflected waves to increase; if the incident wave is compressive then it causes the shock to accelerate, but if the incident wave is an expansion wave then its effect would be to decelerate the shock. For a characteristic shock, the nature of the transmitted wave remains quite similar to that of incident wave, but the nature of the reflected wave is not so. It is noticed that for a weak shock, the jump in its acceleration due to an interaction with a $C^1$ wave can be zero only when the incident wave belongs to the same family as the shock; this is in agreement with a recent work reported in the literature.

Acknowledgement: This work was supported by the U.S. Army Research Laboratory and U.S. Army Research Office under the grants number W911NF-11-1-0399 and W911NF-11-1-0325.

O. Scherzer (otmar.scherzer@univie.ac.at) – Computational Science Center, University Vienna; and RICAM Radon Institute of Computational and Applied Mathematics, Austria

Thursday 2:10pm BA147

Nonconvex Regularization

Abstract: In the paper we present some nonconvex regularization methods. The analysis of the methods requires relaxation and convexification techniques, which are presented. The nonconvex regularization are motivated by a Bayesian view of random sampling errors.
We derive some semigroup concept associated with nonconvex regularization methods and compare it with other solution concepts for the ow equation. Finally we give some applications to dejittering, demo-saicing and other imaging applications.

This is joint work with P. Elbau, M. Grasmair and F. Lenzen.

Larry L. Schumaker (larry.schumaker@gmail.com) – Vanderbilt University Thursday 4:10pm BA119

Spline Spaces and the FEM Method

Abstract: Piecewise polynomials defined on triangulations are a well established tool for solving boundary-value problems with the finite-element method. Here we show that various spaces of splines with some global smoothness can also be effectively used in the FEM method, and have some decided advantages over \( C^0 \) spaces. The key is to use Bernstein-Bézier methods for representing the splines.

In the second part of the talk, we report on very recent results on spaces of splines defined on meshes with hanging vertices. These meshes have the advantage that refinement is greatly simplified, and the resulting spline spaces are much more flexible than traditional splines.

Ralph Showalter (show@science.oregonstate.edu) – Department of Mathematics, Oregon State University Thursday 12:30pm BA119

General Porous Medium Equation as a Multi-phase Methane-hydrate Model

Abstract: A description of the formation and dissolution of methane hydrates in the seabed leads to a general porous medium equation. This free-boundary problem is a first attempt to model the phase transition of methane under conditions of high pressure and low temperature and to characterize its dependence on these conditions. It leads to a Stefan-like problem in which the phase constraint depends on the spatial variable. The theory of the initial-boundary-value problem for this equation is developed by methods of convex analysis. The resolution of the solubility constraint in the numerical simulation is formulated as a nonlinear complementarity constraint and resolved by semi-smooth Newton methods.

Zhisheng Shuai (Zhisheng.Shuai@ucf.edu) – Department of Mathematics, University of Central Florida. Friday 6:10am BA147

Global Dynamical Analysis of an Age-Structured Cholera Model

Abstract: The World Health Organization estimates that there are 3m-5m cholera cases per year with 100,000 deaths spread over 40-50 countries. For example, there has been a recent cholera outbreak in Haiti. Cholera is a bacterial disease caused by the bacterium Vibrio cholera, which has multiple transmission pathways. To better understand the dynamics of cholera, a new PDE model is formulated that incorporates multiple transmission pathways, and both the infection age of infectious individuals and biological age of pathogen in the environment. The basic reproduction number is defined and proved to be a sharp threshold determining that the solutions converge to either the trivial (disease-free) equilibrium or to the unique positive (endemic) equilibrium. Final size relations for cholera outbreaks are derived for simplified models when input and death are neglected.

Joint work with Fred Brauer (UBC, Canada) and Pauline van den Driessche (UVic, Canada).
Global Well-posedness of an Inviscid Three-dimensional Pseudo-Hasegawa-Mima-Charney-Obukhov Model

Abstract: The three-dimensional inviscid Hasegawa-Mima model is one of the fundamental models that describe plasma turbulence. The same model is known as the Charney-Obukhov model for stratified ocean dynamics, and also appears in literature as a simplified reduced Rayleigh-Bénard convection model. The mathematical analysis of the Hasegawa-Mima and of the Charney-Obukhov equations is challenging due to the absence of any smoothing viscous terms, as well as to the presence of an analogue of the vortex stretching terms. In this talk, we introduce and study a model which is inspired by the inviscid Hasegawa-Mima and Charney-Obukhov models, which we call a pseudo-Hasegawa-Mima model. The introduced model is easier to investigate analytically than the original inviscid Hasegawa-Mima model, as it has a nicer mathematical structure. The resemblance between this model and the Euler equations of inviscid incompressible fluids inspired us to adapt the techniques and ideas introduced for the two-dimensional and the three-dimensional Euler equations to prove the global existence and uniqueness of solutions for our model. This is in addition to proving and implementing a new technical logarithmic inequality, generalizing the Brezis-Gallouet and the Berzis-Wainger inequalities. Moreover, we prove the continuous dependence on initial data of solutions for the pseudo-Hasegawa-Mima model. These are the first results on existence and uniqueness of solutions for a model that is related to the three-dimensional inviscid Hasegawa-Mima equations.

This is a joint work with C. Cao and A. Farhat.

Integrable Nonlinear Evolution Equations: Solution by Inverse Scattering Transform

Abstract: The initial-value problems of nonlinear PDE’s, such as the Korteweg-de Vries (KdV), nonlinear Schrödinger (NLS), modified Korteweg-de Vries (mKdV), sine-Gordon (SG), and Landau-Lifschitz (LL) equations, can be solved explicitly by the inverse scattering transform (IST) method. Considering a linear ODE eigenvalue problem containing the initial solution \( u(x,0) \) as a potential, (i) we determine the scattering data consisting of a reflection coefficient \( R(k) \) and discrete eigenvalue data \( \{ \kappa_j, N_j \}_{j=1}^N \), (ii) evolve these data in time, (iii) solve the Marchenko integral equation whose integral kernel is composed of the time evolved scattering data, and then compute the solution \( u(x,t) \) from the solution of the Marchenko equation. For the KdV equation, we thus obtain the following diagram:

\[
\begin{array}{c}
u(x,0) \xrightarrow{\text{direct scattering}} \{ R(k), \{ \kappa_j, N_j \}_{j=1}^N \} \\
\downarrow \text{KdV} \\
u(x,t) \xleftarrow{\text{inverse scattering}} \{ R(k)e^{8ik^3t}, \{ \kappa_j, N_j e^{8\kappa_j^3t} \}_{j=1}^N \} \\
\end{array}
\]

Instead, we can consider the Marchenko integral kernel as scattering data and evolve this kernel in time. The crux of the IST method is that a complicated solution of a nonlinear PDE is converted into a trivial time evolution of scattering data. All it then takes is to have a complete direct and inverse scattering theory of the accompanying linear ODE eigenvalue problem.

In this talk we discuss an explicit solution technique based on separation of variables of the Marchenko integral kernel:

\[
\Omega(x + y; t) = Ce^{-(x+y)A}e^{4itA^2}B,
\]
where \((A, B, C)\) is a triplet of size compatible matrices and \(A\) has only eigenvalues with positive real part. Depending on the integrable PDE, the time factor \(e^{4itA^2}\) varies. We also discuss transformations of the triplets \((A, B, C)\) which leave invariant the solution \(u(x, t)\).

We also discuss the problem of characterizing the scattering data of the AKNS system (the linear ODE eigenvalue problem associated with the above nonlinear PDE). In fact, we obtain a 1,1-correspondence between \(L^1\)-potentials without spectral singularities and a suitable class of Marchenko integral kernels.

We also discuss the discrete counterpart of the inverse scattering problem, where the nonlinear PDE becomes a differential equation in time and a difference equation in position and the linear ODE eigenvalue problem becomes a linear eigenvalue problem for a difference operator.

The results have been obtained in collaboration with Tuncay Aktosun (University of Texas at Arlington) and Francesco Demontis (Università di Cagliari).

Research supported in part by MIUR, RAS, and INdAM-GNCS

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**Gilbert G. Walter** (yggw@hotmail.com) – University of Milwaukee

**Thursday 5:00pm BA147**

**Prolate Spheroidal Wave Functions: Two problems-one solution**

**Abstract:** Prolate spheroidal wave functions arose as solutions to a Sturm-Liouville problem in the 19th century. In the 20th century they were found also to be a solution to an optimization problem (lucky accident). As a result, they have many interesting and unique properties that make them potentially useful in imaging and sampling. But they are difficult to work with and approximation based on them lack some properties one would expect. In this talk we review some of these, and discuss some extensions.

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**Haochao Wang** (hchwang@ucdavis.edu) – University of California, Davis

**Friday 2:40pm BA119**

**Compressive MIMO Radar with Random Sensor Arrays**

**Abstract:** We derive a theoretical framework for the recoverability of targets in the azimuth-range-Doppler domain using random sensor arrays and tools developed in the area of compressive sensing. In one manifestation of our theory we use Kerdock codes as transmission waveforms and exploit some of their peculiar properties in our analysis. This is a joint work with Thomas Strohmer.

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**Yu-wen WANG** (vangyuwen1950@yahoo.com.cn) – Harbin Institute of Petroleum, Harbin, 150027, P.R.China

**Friday 4:20pm BA147**

**Generalized Green Functions and Ill-Posed Quasilinear Two-Point Neumann Boundary Value problems**

**Abstract:** In this paper, we consider the quasilinear two-point Neumann boundary value problem

\[
\begin{cases}
    u''(x) + g(x, u'(x)) = 0, & 0 < xy < 1; \\
    u'(0) = u'(1) = 0,
\end{cases}
\]

where

\[
\int_0^1 g(x, v(x))dx \neq 0, \forall v(\cdot) \in L^2[0, 1].
\]

The problem is ill-posed, we look for the best approximate solution to the problem in following sense. Let

\[ D(A) = \{ u(\cdot) \in H^1(0, 1) : u''(\cdot) \in H^{-1}(0, 1), u'(0) = u'(1) = 0 \}, \]
\[ Au(x) = -u''(x), \quad u(\cdot) \in D(A) \subset L^2[0,1]. \]

For \( u(\cdot) \in D(A), F(u(x)) := g(x, u''(x)) \), \( u_0(\cdot) \in D(A) \) is said to be the best approximate solution to the problem, if
\begin{enumerate}
  \item \( Au_0 = P_{R(A)}(F(u_0)) \);
  \item \( \| u_0 \|_2 = \min \{ \| v \|_2 : Av = P_{R(A)}(F(u_0)), v \in D(A) \} \),
\end{enumerate}
where \( P_{R(A)} \) is the orthogonal projection from \( H^{-1}(0,1) \) onto \( R(A) \subset H^{-1}(0,1) \).

By means of generalized inverse and generalized Green function, below we give the characterize conditions. Let the operator \( A \) defined as above, then following statements are equivalent
\begin{enumerate}
  \item \( u_0(\cdot) \in D(A) \) is the best approximate solution to the problem;
  \item \( u_0(\cdot) \in D(A) \) is the unique solution of the following well-posed two-point Neumann boundary value problem with constraint
    \[
    \begin{cases}
    -u''(x) = g(x, u''(x)) - \int_0^1 g(y, u''(y)) \, dy, \quad 0 < x < 1, \\
    u'(0) = u'(1) = 0, \\
    \int_0^1 u(x) \, dx = 0.
    \end{cases}
    \]
  \item \( u_0(\cdot) \in D(A) \) is the unique solution of the following well-posed integral equation
    \[ u(x) = \int_0^1 G(x,y) g(y, u'(y)) \, dy, \]
where \( G(\cdot, \cdot) : (0,1) \times (0,1) \rightarrow \mathbb{R}^1 \) is the generalized Green function for \( A \).
\end{enumerate}

Let \( \delta(\cdot-x) \) be the Dirac measure at \( x \), the generalized Green function \( G(x,y) \) can be expressed as
\[ G(x,y) = A^+ \delta(y-x), \quad \forall x,y \in (0,1) \]
where \( A^+ \) is the Moore-Penrose generalized inverse of \( A \).

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Glenn F. Webb (glenn.f.webb@vanderbilt.edu) – Mathematics Department, Vanderbilt University  
Thursday 5:00pm  BA119

*The Ensemble Interpretation of Quantum Mechanics and the Two-Slit Experiment*

**Abstract:** An evolution equation model is provided for the two-slit experiment of quantum mechanics. The state variable of the equation is the probability density function of particle positions. The equation has a local diffusion term corresponding to stochastic variation of particles, and a nonlocal dispersion term corresponding to oscillation of particles in the transverse direction perpendicular to their forward motion. The model supports the ensemble interpretation of quantum mechanics and gives descriptive agreement with the Schrödinger equation model of the experiment.

Xiangsheng Xu (xxu0901@yahoo.com) – Department of Mathematics & statistics, Mississippi State University  
Friday 10:30am  BA147

*Existence theory for a class of semiconductor models*

**Abstract:** In this talk we will focus on a class of quantum drift-diffusion models. These models involve fourth-order nonlinear partial differential equations. As a result, classical tools such as the maximum principle are no longer applicable. A new type of functional inequalities is developed. This enables us to establish several existence theorems.
An Approximation of Transient Behavior of Semiconductor Devices by Mixed Finite Element Method and Characteristics-mixed Finite Element Method

Abstract: We consider the mathematical model of two-dimensional semiconductor devices, which is governed by a coupled system of three quasi-linear partial differential equations with initial and boundary values. The elliptic equation is for modeling the electrostatic potential, the two convection-dominated diffusion equations are modeling of the conservation of electron and hole concentrations. Standard mixed finite element method is used for the electrostatic potential equation to approximate both the electrostatic potential and the electric field intensity simultaneously. A characteristics-mixed finite element method is developed for approximating the electron and hole concentrations. Characteristic approximation is applied to handle the convection terms, and a lowest-order mixed finite element spatial approximation is adopted to deal with the diffusion terms. This new scheme is locally conservative on the discrete level. A post-processing step is included in the scheme in which the approximations to the scalar unknowns are improved by utilizing the approximate vector flux. We prove that the numerical solutions converge optimally. Numerical experiment is presented finally to validate the theoretical analysis.

This is a joint work with Y. R. Yuan.

Hong-ming Yin (hyin@math.wsu.edu) – Department of Mathematics, Washington State University Thursday 1:20pm BA119

On American Option-Pricing Model with uncertain volatility

Abstract: In this talk I will discuss a model for American option-pricing with uncertain volatility. We first show that some mathematical results about the existence and uniqueness. Then we derive some properties of the option price.

Ahmed I. Zayed (azayed@condor.dePaul.edu) – Department of Mathematical Sciences, DePaul University Saturday 8:30am BA147

Chromatic Expansions in Function Spaces

Abstract: Chromatic series expansions have recently been introduced in signal analysis as an alternative representation to Taylor series for bandlimited functions and they have been shown to be more useful in practical applications than Taylor series.

In this talk we show how chromatic series can be used to characterize different function spaces and to solve initial-value problems involving certain differential equations.

Fang Zeng (fangzeng1985@gmail.com) – Department of Mathematical Sciences, Applied Mathematics Research Center, Delaware State University, Dover, Delaware 19901. Saturday 9:50am BA147

An inverse electromagnetic scattering problem for cavity
**Abstract:** Compare to the typical exterior inverse scattering problem, we consider an inverse electromagnetic scattering problem of determining the shape of a perfectly conducting cavity from measurement of scattered electric field due to electric dipole sources on a surface inside the cavity which can be called the interior inverse scattering problem. In this talk, we first prove a reciprocity relation for the scattered electric field and a uniqueness theorem for the inverse problem. Then the near field linear sampling method is employed to reconstruct the shape of the cavity. Finally, we provide some preliminary numerical examples to show the viability of the method.

This paper is based on a joint work with Fioralba Cakoni (University of Delaware) and Jiguang Sun (Michigan Technological University).
Computational Analysis of Inverse Problems and Partial Differential Equations
Orlando, May 9–11, 2013

1. A. Aldroubi, Vanderbilt University
2. G. Ambartsoumian, University of Texas at Arlington
3. R. Andreev, CSCAMM, University of Maryland
4. G. Auchmuty, University of Houston
5. R. Balan, University of Maryland, College Park
6. T. Banks, North Carolina State University
7. J. Benedetto, University of Maryland, College Park
8. J. Burns, Virginia Tech
9. J. Cannon, University of Central Florida
10. A. Carasso, National Institute of Standards and Technology
11. J. Chandra, George Washington University
12. X. Chen, University of Maryland, College Park
13. J. T. Davis, Vanderbilt University
14. G. Dogan, Theiss Research, National Institute of Standards of Technology
15. P. DuChateau, Colorado State University
16. P. Eggermont, University of Delaware
17. H. Engl, University of Vienna, Austrian Academy of Sciences, Austria
18. A. S. Erdogan, Fatih University, Istanbul, Turkey and University of Central Florida
19. W. Freeden, University of Kaiserslautern, Germany
20. D. J. Galiffa, Penn State Erie
21. L. Ge, University of Central Florida
22. R. Gilbert, University of Delaware
23. C. Groetsch, Citadel
24. B. Hu, University of Notre Dame
25. Mourad E. H. Ismail, University of Central Florida
26. N. Liao, Vanderbilt University
27. T. Lin, Virginia Tech
28. Y. Lin, University of Alberta, Canada, and Hong Kong Polytechnic University, China
29. F. Liu, Delaware State University
30. Z. Liu, University of Minnesota at Duluth
31. V. Michel, University of Siegen, Germany
32. P. Mikusinski, University of Central Florida
33. D. Mitrea, University of Missouri
34. M. Mitrea, University of Missouri
35. A. Moradifam, Columbia University
36. A. H. M. Murid, Universiti Teknologi Malaysia, Malaysia
37. Z. Nashed, University of Central Florida
38. T. T. Nguyen, University of North Carolina at Charlotte
39. D. O. Olagunju, University of Delaware
40. S. Perez-Esteva, Universidad Nacional Autonoma de Mexico, Mexico
41. Y. Qi, University of Central Florida
42. G. Ramesh, University of Central Florida
43. K. Sadiq, University of Central Florida
44. F. Santosa, University of Minnesota
45. V. D. Sharma, Indian Institute of Technology, India
46. O. Scherzer, RICAM, Austrian Academy of Sciences, Austria
47. L. Schumaker, Vanderbilt University
48. R. E. Showalter, Oregon State University
49. Z. Shuai, University of Central Florida
50. Q. Sun, University of Central Florida
51. A. Tamasan, University of Central Florida
52. E. S. Titi, Weizmann Institute of Science and University of California-Irvine
53. R. Triggiani, University of Virginia
54. C. van der Mee, Universita di Cagliari, Italy
55. G. Walter, University of Wisconsin-Milwaukee
56. H. Wang, University of California, Davis
57. Y. Wang, Harbin Normal University, China
58. G. F. Webb, Vanderbilt University
59. X. Xu, Mississippi State University
60. Q. Yang, Virginia Tech and Shangdong Normal University
61. H. Yin, Washington State University
62. J. Yong, University of Central Florida
63. A. Zayed, DePaul University
64. F. Zeng, Delaware State University
65. Y. Zhu, University of Central Florida
Program

Thursday Morning (May 9, 2013): Registration, Opening (9:00am) and Lectures by Heinz Engl (9:20am) and Paul DuChateau (10:20am) at BA119

Thursday Afternoon (May 9 2013): Two parallel sessions from 12:30pm to 5:50pm and Banquet at LiveOak (6:30pm)

Session A at BA119: Presentations by Ralph Showalter (12:30pm); Hong-min Yin (1:20pm); Yanping Lin (2:10pm); Salvador Perez-Esteva (3:20pm); Larry L. Schumaker (4:10pm); and Glenn F. Webb (5:00pm)

Session B at BA147: Presentations by Willi Freedan (12:30pm); Chuck Groetsch (1:20pm); Otmar Scherzer (2:10pm); John Benedetto (3:20pm); Robert P. Gilbert (4:10pm); and Gilbert G. Walter (5:00pm)

Friday Morning (May 10, 2013): Two parallel sessions from 8:30am to 12:10pm

Session A at BA 119: Presentations by Akram Aldroubi (8:30am); Fadil Santosa (9:20am); H. T. Banks (10:30am); and Edriss S. Titi (11:20am)

Session B at BA 147: Presentations by Tao Lin (8:30am); Zhuangyi Liu (9:20am); Xiangsheng Xu (10:30am); and Mourad E. H. Ismail (11:20am)

Friday Afternoon (May 10, 2013): Two parallel sessions from 1pm to 6:40pm

Session A at BA 119: Presentations by Ali H. M. Murid (1:00pm); John A. Burns (1:50pm); Haichao Wang (2:40pm); Radu Balan (3:30pm); Alfred Carasso (4:20pm); Gunay Dogan (5:10pm); Xuemei Chen (5:40pm); and Jacqueline T. Davis (6:10pm)

Session B at BA 147: Presentations by Bei Hu (1:00pm); Giles Auchmuty (1:50pm); Gaik Ambartsumian (2:40pm); Fangshan Liu (3:30pm); Yu-wen Wang (4:20pm); Naian Liao (5:10pm); Qing Yang (5:40pm); and Zhisheng Shuai (6:10pm)

Saturday Morning (May 11, 2013): Two parallel sessions from 8:30am to 12:30pm

Session A at BA 119: Presentations by Cornelis van der Mee (8:30am); Abdullah S. Erdogan (9:20am); Amir Moradifam (9:50am); Roman Andreev (10:40am); V. D. Sharma (11:10am); and Paul Eggermont (11:40am).

Session B at BA 147: Presentations by Ahmed I. Zayed (8:30am); Trung Thanh Nguyen (9:20am); Fang Zeng (9:50am); Daniel J. Galiffa (10:40am); Kamran Sadiq (11:10am); and Volker Michel (11:40am).

Classrooms BA 212 and BA207 are reserved for you to use during the conference period.