THE GEORGE WASHINGTON UNIVERSITY STUDENT CHAPTER OF SIAM

Spring 2023 Conference on Applied Mathematics

Washington DC

April 8, 2023

Timetable

9:00-9:30
Registration and Breakfast

9:30-9:45
Open Remark: Frank E. Baginski, The George Washington University

9:45-10:15
Chong Wang, Washington and Lee University

10:15-10:45
Guillaume Bonnet, University of Maryland, College Park

1045-11:00
Break

11:00-11:30
Yanfang Liu, The George Washington University

11:30-12:00
Madhu Gupta, George Mason University

12:00-12:10
Picture Time

12:10-1:30
Lunch

1:30-2:00
Mengzi Xie, University of Maryland, College Park

2:00-2:30
David Sayre, George Mason University

2:30-2:45
Break

2:45-3:15
Shuo Yan, University of Maryland, College Park

3:15-6:00

Break

6:00

Dinner

Chong Wang
Washington and Lee University

Title

Periodic Minimizers of A Ternary Nonlocal Isoperimetric Problem

Abstract

We study a two-dimensional ternary inhibitory system. The free energy functional combines an interface energy favoring micro-domain growth with a Coulomb-type long range interaction energy which prevents micro-domains from unlimited spreading. Here we consider a limit in which two species are vanishingly small, but interactions are correspondingly large to maintain a nontrivial limit. In this limit two energy levels are distinguished: the highest order limit encodes information on the geometry of local structures as a two-component isoperimetric problem, while the second level describes the spatial distribution of components in global minimizers. We provide a sharp rigorous derivation of the asymptotic limit, both for minimizers and in the context of Gamma-convergence. Geometrical descriptions of limit configurations are derived. The main difficulties are hidden in the optimal solution of two-component isoperimetric problem: compared to binary systems, not only it lacks an explicit formula, but, more crucially, it can be neither concave nor convex on parts of its domain.

Yanfang Liu
The George Washington University

Title

Deterministic-Statistical Approach for an Inverse Acoustic Source Problem using Multiple Frequency Limited Aperture Data

Abstract

We propose a deterministic-statistical method for an inverse source problem using multiple frequency limited aperture far field data. The direct sampling method is used to obtain a disc such that it contains the compact support of the source. The Dirichlet eigenfunctions of the disc are used to expand the source function. Then the inverse problem is recast as a statistical inference problem and the Bayesian inversion is employed to reconstruct the coefficients of the eigen-expansion for the source function. The stability of the statistical inverse problem with respect to the measured data is justified in the sense of Hellinger distance. A preconditioned Crank-Nicolson (pCN) Metropolis-Hastings (MH) algorithm is implemented to explore the posterior density function. Numerical examples show that the proposed method is effective for both smooth and non-smooth sources given limited aperture data.

Madhu Gupta
George Mason University

Title

Nonlinear Reconstruction of Optical Parameters in Photoacoustic Tomography

Abstract

We will discuss an optimization framework for the reconstruction of single-photon absorption and two-photon absorption coefficients in photoacoustic computed tomography (PACT). The framework comprises of mini- mizing an objective functional involving least squares fit of the interior pressure field data corresponding to two boundary source functions, where the absorption coefficients and the photon density are related through a semi-linear elliptic partial differential equation (PDE) arising in photoacoustic tomography. The objective functional consists of an L1- regularization term that promotes sparsity patterns in absorption coefficients and H1-regularizer to reduce the artifacts in the reconstruction. We provide a proof of existence and uniqueness of a solution to the semi-linear PDE. Further, a proximal method, involving a Picard solver for the semi-linear PDE and its adjoint, is used to solve the optimization problem. Several numerical experiments are presented to demonstrate the effectiveness of the proposed framework. We will conclude the presentation by discussing another framework where the minimizing functional consist of fractional Sobolev norm of absorption coefficient and diffusion coefficient as a regularizer for better reconstruction.

Guillaume Bonnet
University of Maryland, College Park

Title

Virtual element method for nondivergence form elliptic equations

Abstract

Problems in nondivergence form arise from a wide range of applications such as stochastic optimal control, nonlinear elasticity, and image processing. Their numerical discretisation is notoriously challenging due to the lack of notion of weak solutions based on variational principles. We consider the model problem of non-divergence form elliptic equations arising from the linearization of fully nonlinear equations, such as the Hamilton-Jacobi-Bellman equation. The model problem is well-posed under the Cordes conditions thanks to the Miranda-Talenti inequality, bounding the L^2 norm of the Hessian of H^2 functions with zero trace on convex domains by their laplacian. We exploit the availability of H^2 conforming Virtual Element spaces to design a VEM based on an equivalent variational problem whose stability follows directly from the availability of the Miranda-Talenti inequality. The resulting VEM is proven to converge optimally in the H^2 norm, as confirmed by numerical experiments performed using the DUNE-VEM package.

Mengzi Xie
University of Maryland, College Park

Title

The Smoluchowski-Kramers approximation of nonlinear wave equations with variable friction

Abstract

We study the validity of a large deviation principle for a class of stochastic nonlinear damped wave equations, of Klein-Gordon type, in the joint small mass and small noise limit. The friction term is assumed to be state dependent.

Shuo Yan
University of Maryland, College Park

Title

Random perturbations of Hamiltonian systems

Abstract

We consider asymptotic problems concerning small random perturbations of Hamiltonian systems. In the case of additive white-noise-type perturbations, results such as large deviations and the averaging principle can be obtained on different time scales (most of the classical results in this direction are due to Freidlin and Wentzell). The main difficulties arise when the Hamiltonian has multiple critical points, in particular, saddle points. Our new results concern the case of fast oscillating perturbations.

David Sayre
George Mason University

Title

An Optimal Control Framework for Neuromorphic Imaging

Abstract

Event or Neuromorphic cameras are novel biologically inspired sensors that record data based on the change in light intensity at each pixel asynchronously. They have a temporal resolution of microseconds. This is useful for scenes with fast moving objects that can cause motion blur in traditional cameras, which record the average light intensity over an exposure time for each pixel synchronously. We present a bilevel optimization based variational framework for neuromorphic imaging.