

# GLSIAM 2008: Snapshots of Applied Mathematics

- 10 – 11 am      Coffee, registration, and poster set-up.
- 11 am – Noon      Gregory Beylkin, University of Colorado at Boulder  
Title: *Fast algorithms for adaptive application of  
integral operators in high dimensions.*
- Noon – 1:30 pm      Lunch on your own.
- 1:30 – 2:30 pm      Lenya Ryzhik, University of Chicago  
Title: *Reaction-diffusion fronts in random media.*
- 2:30 – 3 pm      Coffee break.
- 3 – 4 pm      Keith Promislow, Michigan State University  
Title: *Pore formation in Polymer Electrolytes.*
- 4 – 4:30 pm      Coffee break.
- 4:30 – 5:30 pm      Alfred Hero, University of Michigan  
Title: *Blind sparsity constrained inverse problems in  
volumetric imaging.*

# Abstracts

**Speaker:** Gregory Beylkin

**Title:** Fast algorithms for adaptive application of integral operators in high dimensions.

**Abstract:** In physics, chemistry and other applied fields, many problems may be formulated using integral equations, typically involving Green's functions as their kernels. Often such formulations are preferable to those via partial differential equations (PDEs) by avoiding, for example, issues associated with the high condition number of a PDE formulation.

This talk will describe adaptive multiresolution algorithms for applying integral operators with radially symmetric kernels in high dimensions. Many important operators, including certain singular operators, such as the projector on divergence-free functions, fall into the class for which our approach yields fast adaptive algorithms. In dimensions two and higher we represent kernels in a separated form by approximating them by a sum of Gaussians. Such representations require surprisingly few terms and provide approximations in operator norm for any finite but arbitrary accuracy.

**Speaker:** Lenya Ryzhik

**Title:** Reaction-diffusion fronts in random media

**Abstract:** It is well known that scalar reaction-diffusion equations in homogeneous media admit special planar front solutions which propagate with a constant speed. They are stable for a large class of nonlinearities. Similar results have been established in periodic media. I will discuss generalizations of the notion of a traveling front to general heterogeneous media and, in particular, random media, as well as stability of those fronts when the nonlinearity is of the ignition type. This is a joint work with J. Nolen, J.-M. Roquejoffre and A. Mellet.

**Speaker:** Keith Promislow

**Title:** Pore formation in Polymer Electrolytes

**Abstract:** Much of our quality of life in the 21st century will depend upon how efficiently we use our energy resources. The efficient conversion of energy from one form to another, particularly solar, chemical or thermal to electric, requires detailed nano-structured morphology. The polymer electrolytes in Polymer Electrolyte Membrane (PEM) fuel cells conduct

protons while forming a barrier for electrons and molecular gases. We provide experimental evidence that they dynamically form a complex nanostructured pore network when exposed to liquid water, and provide a novel mathematical model for the solvent-polymer interaction which incorporates the functionalization of the polymer sidechains. We show that our model resides within a mathematical class of energies, which we call functionalized Lagrangians, which have a rich structure, preserving the critical points of the old Lagrangian, while generating new critical points (here the pore network) in a controllable, if hysteric, manner.

**Speaker:** Alfred Hero

**Title:** Blind sparsity constrained inverse problems in volumetric imaging.

**Abstract:** Magnetic resonance force microscopy is an emerging inverse problem in which the object domain has a natural sparseness property. See-through-wall radar imaging is another application where sparsity naturally occurs in the object domain. When the forward operator is only partially known the blind sparsity constrained problem becomes relevant. We will describe approaches to solving these naturally sparse inverse problems that rely on physics modeling, sparsity penalization, and optimization.