Third Conference on Analysis and Applied Mathematics

(CAAM 3)

Sai Gon University

273 An Duong Vuong, P.3, Q.5, TP.HCM, VN

December 19 - 20, 2022

Local organizers: Chi Phuong Kieu (Saigon University), Quan Pham (Saigon University).

CAAM organizers: Tuoc Phan (University of Tennessee - Knoxville), Hung Tran (University of Wisconsin - Madison).

Conference secretary: Huy Hoang Truong, Email: thhuy at sgu dot edu dot vn.

Homepage: `https://web.math.utk.edu/~phan/CAAM/`

CAAM 3 - Program

Main Session 1: December 19, 2022.

- 7:40 - 8:00: Registration, coffee, meet, and greet.
- 8:00 - 8:10: Welcome remarks by SGU and organizers.
- 8:10 - 9:00: Professor **Xia Chen** (University of Tennessee, Knoxville, TN, USA)
  Title: *Laplace transform and Brownian functionals.*
- 9:15 - 10:05: Dr. **Timo Sprekeler** (National University of Singapore, Singapore)
  Title: *Homogenization of elliptic equations in nondivergence-form: optimal convergence rates and numerical homogenization.*
- 10:20- 10:50: Coffee break.
- 10:50 - 11:40: Professor **Son Quang Ta** (Sai Gon University, Ho Chi Minh City, Vietnam)
  Title: *Subdifferentials, approximate subdifferentials and applications to nonsmooth optimization Problems.*
- 12:00 - 2:00 Lunch break.

Parallel Session 1: December 19, 2022.

- 2:00 - 2:25: Dr. **Cam Hong Thi Luong** (Sai Gon University, Ho Chi Minh City, Vietnam).
  Title: *A posteriori error estimates for discontinuous Galerkin method to the elasticity problem.*
- 2:35 - 3:00: Ms. **Thuy Le** (University of North Carolina - Charlotte, North Carolina, US)
  Title: *Convexification method for the 3D inverse scattering problem in the frequency domain.*
- 3:10 - 3:50: Coffee Break
- 3:50 - 4:15: Dr. **Phong Hong Luu** (Binh Tay Middle School, Ho Chi Minh City, Vietnam)
  Title: *Determination of terminal wave amplitude in a viscous medium.*

Parallel Session 2: December 19, 2022.

- 2:00 - 2:25: Professor **Anh Tuan Nguyen** (Ho Chi Minh City University of Technology, Ho Chi Minh City, Vietnam)
  Title: *Two phase Stefan problem for the solidification of urea droplets under convection cooling.*
- 2:35 - 3:00: Dr. **Thoa Thieu** (M3AI Laboratory, Wilfrid Laurier University, Waterloo, Canada)
  Ttitle: *Lattice models for coupled active-passive pedestrian dynamics.*
- 3:10 - 3:50: Coffee Break
- 3:50 - 4:15: Dr. **Liet Vo** (University of Illinois at Chicago, Illinois, US)
  Title: *Chorin projection methods for stochastic Stokes equations.*

Main Session 2: December 20, 2022.

- 7:40 - 8:00: Coffee and discussion
- 8:00 - 8:50: Professor **Triet Minh Le** (Sai Gon University, Ho Chi Minh City, Vietnam)
  Title: *On backward problems for some nonlinear parabolic equations with fractional derivatives.*
- 9:05 - 9:55: Dr. **Uyen Hoang Pham** (University of Economics and Law, Ho Chi Minh City, Vietnam)
  Title: *PLS-SEM and business performance.*
- 10:10 - 10:40: Coffee break
- 10:40 - 11:30: Professor **Xiaobing Feng** (University of Tennessee, Knoxville, TN, USA)
  Title: *Fully nonlinear PDEs and their numerical solutions.*

Conclusion remarks: December 19, 2022

- 11:45 - 12:00: Remarks by organizers and see you again in CAAM - 4.

Chairs of sessions

- Main Session 1: Hung Tran.
- Main Session 2: Tuoc Phan.
- Parallel Session 1: Triet Le.
- Parallel Session 2: Son Ta (first two talks), Anh Tuan Nguyen (last talk).

Titles and Abstracts

Speaker: Xia Chen (University of Tennessee, Knoxville, TN, USA)

Title: *Laplace transform and Brownian functionals*

Abstract: Laplace transform has been widely applied to engineering mathematics. Its historic impact in probability came with a short paper by Darling and Kac (1957) on the Brownian occupation times. In this talk, I will illustrate how this tool can be wisely used in solving some interesting problems in probability. Most of the talk requires no background of the audience beyond an undergraduate probability course.

Speaker: Xiaobing Feng (University of Tennessee, Knoxville, TN, USA)

Title: *Fully nonlinear PDEs and their numerical solutions*

Abstract: Fully nonlinear PDEs are referred to as the class of nonlinear PDEs which are nonlinear in the highest order derivatives of the unknown functions appearing in the equations, they arise from many fields in science and engineering such as astrophysics, antenna design, differential geometry, geostrophic fluid dynamics, materials science, mathematical finance, meteorology, optimal transport, and stochastic control. This class of PDEs is known to be very difficult to study analytically and to approximate numerically. In this talk, I shall first refresh some PDE background and then discuss some latest advances in developing efficient numerical methods for the fully nonlinear second (and first) order PDEs such as the Monge-Ampere type equations, Hamilton-Jacobi, and Hamilton-Jacobi-Bellman equations. The focus of the talk will be on discussing various numerical approaches/methods/ideas and their pros and cons for constructing numerical methods which can reliably approximate viscosity solutions of fully nonlinear PDEs. Numerical experiments and application problems as well as open problems in numerical fully nonlinear PDEs will also be presented.

Speaker: Phong Luu Hong (Binh Tay Middle School, Ho Chi Minh City, Vietnam)

Title: *Determination of terminal wave amplitude in a viscous medium*

Abstract: The time fractional wave equations arise in engineering, in physics, chemistry, medicine and finance, and they describe anomalous diffusion, sub-diffusion processes and relaxation phenomena in complex viscoelastic materials. In this report, we talk about a final value problem for time fractional wave equations involving Caputo's fractional derivative of order $1 < \alpha < 2$ in a bounded domain $\Omega \subset \mathbb{R}^d$ with $d = 1, 2, 3$. In general, the above problem is ill-posed in the sense of Hadamard. Hence, regularization is necessary to obtain a

stable approximation for the problems. The, we establish the existence and uniqueness of the approximated solution and obtain its convergence rate of Hölder type in some certain spaces. Finally, a numerical experiment is given to illustrate the effectiveness of our regularization method.

Speaker: Thuy Le (University of North Carolina - Charlotte, North Carolina, US)

Title: *Convexification method for the 3D inverse scattering problem in the frequency domain*

Abstract: We develop the convexification method to solve the 3D inverse scattering problem for the Helmholtz equation. The name of convexification is suggested by the fact that we involve a suitable Carleman weight function into the nonconvex least square functional to obtain a new functional, which is strictly convex. This convexifying phenomenon is rigorously proved by employing Carleman estimates. Next, we prove that the minimizer of this convex Carleman weighted functional can be reached by the well-known gradient descent method. More importantly, we prove that this minimizer converges to the true solution of the system of PDEs as the noise contained in the data tends to 0. Numerical examples will be presented.

Speaker: Triet Minh Le (Sai Gon University, Ho Chi Minh City, Vietnam)

Title: *On backward problems for some nonlinear parabolic equations with fractional derivatives*

Abstract: In recent years, fractional partial differential equations have received great attention both in analysis and application. The equations containing fractional derivatives can be used in modeling several phenomena in different areas of science such as physics, biology, chemistry, engineering, and control theory so the fractional computation is increasingly attracted to mathematicians. In this talk, we wish to present two backward problems including the problem of recovering the historical distribution for nonlinear time - fractional diffusion equations with random noise and the backward problem for a fractional pseudo - parabolic problem with a nonlinear source term. As we known, these backward problems are severely ill-posed in Hadamard's sense. As a result, we apply some effective techniques to approximate the exact solutions of these problems. Finally, we obtain the convergence rate of the approximate solutions under some a priori conditions on the exact solutions. The talk is based on the joint work with Tu Quoc Tran and Huy Q. Nguyen (Sai Gon University).

Speaker: Cam Hong Thi Luong (Sai Gon University, Ho Chi Minh City, Vietnam)
Title: *A posteriori error estimates for discontinuous Galerkin method to the elasticity problem*
Abstract: This work concerns with the discontinuous Galerkin (DG) method for the time-dependent linear elasticity problem. We derive the a posteriori error bounds for semidiscrete and fully discrete problems, by making use of the stationary elasticity reconstruction technique which allows to estimate the error for time-dependent problem through the error estimation of the associated stationary elasticity problem. For fully discrete scheme, we make use of the backward-Euler scheme and an appropriate space-time reconstruction. The technique here can be applicable for a variety of DG methods as well.

Speaker: Anh Tuan Nguyen (Ho Chi Minh City University of Technology, Ho Chi Minh City, Vietnam)
Title: *Two phase Stefan problem for the solidification of urea droplets under convection cooling*
Abstract: The prilling technique is frequently used to make granular urea and ammonium nitrate. This basic procedure involves spraying a liquid flow from the top of a tower. At the same time, a stream of cooling air collected from the surrounding is fed from the bottom. The generated droplets fall counter-currently and become solid due to the heat removal by the cooling air. The process produces spherical particles with a nearly uniform size. In practice, prilling towers easily suffer operating issues due to incomplete solidification. Because of the poor efficiency of the solidification, a low-quality structure is generated, resulting in productivity and profit losses. Despite of the importance of the process, only a few studies have been conducted on the modeling of a prilling tower. Therefore, in this report, the solidification of urea particle is considered as a two-phase Stefan problem, in which the heat fluxes occur in both two phases, liquid and solid. The cooling and solidification are treated as one process from liquid droplets to complete solid particles instead of dividing into three time intervals. About the hydrodynamic of the process, the particles are assumed to be quickly attain the terminal velocity. This velocity is used to estimate the convective heat transfer coefficient. Boundary condition is the convection cooling with air. The two-phase Stefan problem describing the solidification of urea particles can be solved numerically using the enthalpy method. Joint work with Kim Thanh Vy Ha, Quoc-Lan Nguyen, Van-Vinh Dang, Van-Han Dang, Le-Na T. Pham.

Speaker: Uyen Hoang Pham (University of Economics and Law, Vietnam National University of Hochiminh City, Ho Chi Minh City, Vietnam)
Title: *PLS-SEM and business performance.*

Abstract: Structural Equation Models is a statistical approach for modeling complex multivariable relationships among observed and latent variables. And The Partial Least Squares (PLS) method to Structural Equation Models (also known as PLS-SEM), which is proposed as a component-based estimation method (Wold , 1975), has been gradually developed and used in many fields such as ecology, social sciences, economics. This presentation shows the effectiveness of PLS-SEM in business performance evaluation with a dataset of financial ratios divided into 4 groups: Profitability ratios, Liquidity ratios, Activity ratios, Debt ratios. The study investigates the causal relationship among financial indicators and predicting financial performance for enterprises. In terms of making financing decisions, these models also enable banks and investors to more precisely identify potential businesses.

Speaker: Timo Sprekeler (National University of Singapore, Singapore)
Title: *Homogenization of elliptic equations in nondivergence-form: optimal convergence rates and numerical homogenization*

Abstract: Considering periodic homogenization of the elliptic equation $-A(x/\varepsilon) : D^2u^\varepsilon = f$ in a smooth domain Ω subject to the Dirichlet boundary condition $u^\varepsilon = g$ on $\partial\Omega$, we are interested in characterizing those diffusion matrices A for which $(u^\varepsilon)_{\varepsilon>0}$ converges to the solution of the homogenized problem with L^∞-rate $\mathcal{O}(\varepsilon^2)$ for all sufficiently regular f, g. Such diffusion matrices, which are said to be of type-ε^2, are of particular interest as the optimal L^∞-rate in the generic case is only $\mathcal{O}(\varepsilon)$. Whereas type-ε^2 diffusion matrices can be characterized via the third-order homogenized tensor, we are seeking more explicit characterizations. In the first part of this talk, we provide a new class of type-ε^2 diffusion matrices, confirming a conjecture posed by Guo and Tran, and give a complete characterization of diagonal type-ε^2 diffusion matrices in two dimensions.

In the second part of this talk, we discuss the numerical homogenization of linear elliptic equations in nondivergence-form with multiscale coefficients beyond periodicity and scale separation via local orthogonal decomposition.

Speaker: Son Quang Ta (Sai Gon University, Ho Chi Minh City, Vietnam)
Title: *Subdifferentials, approximate subdifferentials and applications to nonsmooth optimization problems*

Abstract: This talk aims to introduce some new results on approximate subdifferentials for locally Lipschitz functions. The content of the talk is divided into two parts. The first one is devoted to the basic results on subdifferentials for convex functions and locally Lipschitz functions. Characterizations of solutions or ε-solutions for nonsmooth optimization problems are recalled. In the second part we propose a new kind of approximate subdifferential for locally Lipschitz functions, say ε-quasi-subdifferential. Several properties of this subdifferential are investigated. Calculus rules are established. Approximate optimality conditions for a class of nonsmooth optimization problems are introduced. Examples are also given.

Speaker: **Thoa Thieu** (M3AI Laboratory, Wilfrid Laurier University, Waterloo, Canada)

Title: *Lattice models for coupled active-passive pedestrian dynamics*

Abstract: We study models for coupled active-passive pedestrian dynamics. In particular, we introduce two lattice models for active-passive pedestrian dynamics. In the first model, using descriptions based on the simple exclusion process, we study the dynamics of pedestrian escape from an obscure room in a lattice domain with two species of particles (pedestrians). The main observable is the evacuation time as a function of the parameters characterizing the motion of the active pedestrians. Our Monte Carlo simulation results show that the presence of the active pedestrians can favor the evacuation of the passive ones. We interpret this phenomenon as a discrete space counterpart of the so-called drafting effect. In a second model, we consider again a microscopic approach based on a modification of the simple exclusion process formulated for active-passive populations of interacting pedestrians. The model describes a scenario where pedestrians are walking in a built environment and enter a room from two opposite sides. For such a counterflow situation, we have found out that the motion of active particles improves the outgoing current of the passive particles.

Speaker: **Liet Vo** (University of Illinois at Chicago, Illinois, US)

Title: *Chorin projection methods for stochastic Stokes equations*

Abstract: In this talk, I will discuss the two fully discrete Chorin-type projection methods for the stochastic Stokes equations with general multiplicative noise. The first scheme is the standard Chorin scheme and the second one is a modified Chorin scheme which is designed by employing the Helmholtz decomposition on the noise function at each time step to produce a projected divergence-free noise and a "pseudo pressure" after combining the original pressure and the curl-free part of the decomposition. An $O(k^{\frac{1}{4}})$ rate of convergence is proved for the standard Chorin scheme, which is sharp but not optimal due to the use of general noise, where k denotes the time mesh size. On the other hand, an optimal convergence rate $O(k^{\frac{1}{2}})$ is established for the modified Chorin scheme. The fully discrete finite element methods

are formulated by discretizing both semi-discrete Chorin schemes in space by the standard finite element method. Suboptimal order error estimates are derived for both fully discrete methods. It is proved that all spatial error constants contain a growth factor $k^{-\frac{1}{2}}$, where k denotes the time step size, which explains the deteriorating performance of the standard Chorin scheme when $k \to 0$.