

# Conference on Analysis and Applied Mathematics - 2020 (Second CAAM)

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

**Due to the Covid-19, the conference is hosted virtually  
on zoom**

Zoom link (passcode required):  
<https://tennessee.zoom.us/j/97194287044>

December 18 - 19, 2020

**Organizers:** Triet Le (Saigon University), Linh Nguyen (University of Idaho), Truyen Nguyen (The University of Akron), Quan Pham (Saigon University), Tuoc Phan (University of Tennessee - Knoxville), Hung Tran (University of Wisconsin - Madison)

**Homepage:** <http://www.math.utk.edu/~phan/CAAM/>

# Second CAAM - Program

(Zoom room: announced in <http://www.math.utk.edu/~phan/CAAM/> and by e-mail)

## Day 1: December 18, 2020

- 7:40 - 8:00: Coffee, meet and greet
- 8:00 - 8:10: Welcome remarks by organizers and SGU
- 8:10 - 9:00: Professor **Xuan Hung Nguyen** (Ho Chi Minh City University of Technology, Ho Chi Minh City, VN)  
*Title: Topology optimization based on polytopal elements for additive manufacturing*
- 9:15 - 10:05: Professor **Loc Nguyen** (University of North Carolina at Charlotte, North Carolina, US)  
*Title: A convergent numerical method to recover the initial condition of nonlinear parabolic equations from lateral Cauchy data*
- 10:20- 10:40: Coffee break and discussion
- 10:40 - 11:30: Professor **Dinh-Liem Nguyen** (Kansas State University, Kansas, US)  
*Title: Advances in sampling methods for inverse scattering problems*
- 11:40 - .... Lunch break and free afternoon.

## Day 2: December 19, 2020

- 7:40 - 8:00: Coffee and chat
- 8:00 - 8:50: Dr. **Khoa Le** (Technische Universität Berlin, Germany)  
*Title: On the stochastic heat equation with distributional drift*
- 9:05 - 9:55: Professor **Thi-Thao-Phuong Hoang** (Auburn University, Alabama, USA)  
*Title: Domain decomposition-based exponential time differencing methods for stiff evolution problems*
- 10:10 - 10:30: Break and discussion
- 10:30 - 11:20: Professor **Ky Dang Luong** (Qui Nhon University, Qui Nhon, VN)  
*Title: New Hardy spaces of Musielak-Orlicz type and some related problems*
- 11:35 - 11:50: Conclusion Remarks and see you again in CAAM 2022 (Organizers)

# Titles and Abstracts

**Speaker:** **Thi-Thao-Phuong Hoang** (Auburn University, Alabama, USA)

**Title:** *Domain decomposition-based exponential time differencing methods for stiff evolution problems*

**Abstract:** Exponential integrators, among them the Exponential Time Differencing (ETD) methods, provide highly accurate and stable numerical solutions for stiff evolution equations. The cost of these methods is obviously dominated by the computing of matrix exponentials and their products with vectors. The recent development of efficient algorithms for the action of matrix exponentials has increased the effectiveness of ETD methods. To further accelerate the exponential time integration, one can take advantage of parallel and high-performance computing. Direct parallelization at the algebraic level is one possibility, however it usually requires a high communication volume since the matrix exponential is global and dense. A different approach is to use domain decomposition techniques and solve a sequence of smaller-sized subdomain problems, in which the matrix exponentials are computed locally and in parallel. In this talk, we first present the localized ETD methods based on overlapping domain decomposition for a class of semilinear parabolic equations with the well-known Allen-Cahn equation as a special case. Then we develop the localized ETD Runge-Kutta schemes for the rotating shallow water equations and discuss their numerical performance compared to the classic explicit Runge-Kutta algorithms.

**Speaker:** **Khoa Le** (Technische Universität Berlin, Germany)

**Title:** *On the stochastic heat equation with distributional drift*

**Abstract:** It is striking that an addition of a noise force to an ill-posed deterministic system can create a well-posed stochastic system. The phenomenon is called regularization by noise. In this talk, we will discuss the stochastic heat equation with a distributional drift driven by a whitenoise in dimension one. If the drift belongs to a Besov space with some suitable regularity and integrability, the equation has a unique solution. The result includes the skew stochastic heat equation which corresponds to a Dirac delta drift. The talk is based on a recent joint work with Siva Athreya, Oleg Butkovsky and Leonid Mytnik.

**Speaker:** Ky Dang Luong (Qui Nhon University, Qui Nhon, VN)

**Title:** *New Hardy spaces of Musielak-Orlicz type and some related problems*

**Abstract:** In this talk, we will present some our recent results on the Hardy spaces of Musielak-Orlicz type and the commutators of singular integral operators on some function spaces.

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**Speaker:** Hung X. Nguyen (Ho Chi Minh City University of Technology, Ho Chi Minh City, VN)

**Title:** *Topology optimization based on polytopal elements for additive manufacturing*

**Abstract:** Polytopal elements, including polygonal elements for a two-dimensional case and polyhedral elements for a three-dimensional case, are adopted to mesh material domains with high complexity. In our recent work [1], polytopal composite finite elements (PCEs), which were proposed to model the mechanical behavior of compressible and incompressible materials, could pass the patch test and satisfy the inf-sup stability with high accuracy. The PCEs were constructed with a polynomial projection of compatible strain fields through the least-squares approximation. For incompressible materials, volumetric locking arises when the Poisson's ratio close to being 0.5, leading to the over stiffening of incompressible material elements. The volumetric locking phenomenon occurs when a fully integrated element (e.g., Q4 elements with 4 quadrature points or H8 elements with 8 quadrature points) is employed. One well-known solution to the volumetric locking is to couple pressure unknowns together with displacement unknowns. However, this way requires additional unknowns in the system of linear equations, thus require large storage and cost expensively. Fortunately, PCEs, which were purely based on displacement formulation without the additional unknowns, could overcome the over stiffening to accurately model incompressible materials. The moving morphable bar (MMB) approach [2], which has been proposed for structural optimization recently, has advantages: (1) using a small number of design variables; (2) accurately capturing structural-boundary features; (3) easy control of structural feature sizes; and (4) direct multiscale design of porous structures without material homogenization, connector constraints, and local volume constraints [3]. In this study, we present an efficient computational tool using a combination of PCEs and MMBs to model and design incompressible materials (i.e., rubbers), but it can be extended to other material models. Especially, the presentation emphasizes the direct multiscale design of porous structures (i.e., biology soft tissues) for additive manufacturing techniques. The idea is to project adaptive geometric components (AGCs) onto a fixed mesh of PCEs. The structure is simultaneously optimized

at both macro-structural and micro-structural scales by directly optimizing geometry parameters of AGCs. Some numerical examples are investigated to verify the effectiveness of the proposed approach.

## References

- 1 H. Nguyen-Xuan, K.N. Chau, K.N. Chau, *Polytopal composite finite elements*, Comput. Methods Appl. Mech. Eng. 355 (2019) 405-437. doi:10.1016/j.cma.2019.06.030.
- 2 V.N. Hoang, G.W. Jang, *Topology optimization using moving morphable bars for versatile thickness control*, Comput. Methods Appl. Mech. Eng. 317 (2017) 153-173. doi:10.1016/j.cma.2016.12.004.
- 3 V.-N. Hoang, N.-L. Nguyen, P. Tran, M. Qian, H. Nguyen-Xuan, *Adaptive concurrent topology optimization of cellular composites for additive manufacturing*, JOM. 72 (2020) 2378-2390. doi:10.1007/s11837-020-04158-9.

**Speaker: Dinh-Liem Nguyen** (Kansas State University, Kansas, US)

**Title:** *Advances in sampling methods for inverse scattering problems*

**Abstract:** Broadly speaking, inverse scattering problems are the problems of determining information about an object (scatterer) from measurements of the field scattered from that object. These problems have applications to such diverse areas as nondestructive testing, geophysical exploration, medical imaging, and radar. Sampling methods, which were initiated by Colton and Kirsch in 1996, have become a major and efficient approach for solving inverse scattering problems. Compared with iterative optimization-based methods, sampling methods are fast, non-iterative, and essentially do not require a priori information about the unknown scatterer. In this talk, we will discuss some of our recent results on new types of sampling methods for inverse scattering problems.

**Speaker: Loc Nguyen** (University of North Carolina - Charlotte, NC, US)

**Title:** *A convergent numerical method to recover the initial condition of nonlinear parabolic equations from lateral Cauchy data*

**Abstract:** We propose a new numerical method for the solution of the problem of the reconstruction of the initial condition of a quasilinear parabolic equation from the measurements of both Dirichlet and Neumann data on the boundary of a bounded domain. Although this problem is highly nonlinear, we do not require an initial guess of the true solution. The key in our method is the derivation of a boundary value problem for a system of coupled quasilinear elliptic equations whose solution is the vector function of the spatially dependent

Fourier coefficients of the solution to the governing parabolic equation. We solve this problem by an iterative method. The global convergence of the system is rigorously established using a Carleman estimate. Numerical examples are presented.

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3	Hung	Tran	UW Madison	Professor
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6	Luan	Hoang	Texas Tech University	Professor
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16	Liet	Vo	University of Tennessee	Graduate Student
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