



# University of Houston SIAM and AMS Student Chapters at Department of Mathematics

## 2014 Graduate Student Paper Presentations

Speakers: Graduate Students, Department of Mathematics

**Friday, April 4, 2014  
12.30-5 pm  
SEC 103**

### Details of the presentations

UH SIAM and UH AMS invite you to attend second Graduate Students Paper Presentations Event of the Department of Mathematics at University of Houston. A panel of professors (Drs. Heier, Labate, Onofrei, Ott and Tomforde) will evaluate the talks, and four presentations will be awarded. The details the talks are as follows:

1. **Tan Ren (1-1.15 pm) - Runge-Kutta Discontinuous Galerkin Method for Traffic Flow Model on Networks**

#### Abstract

We propose a Runge-Kutta (RK) discontinuous Galerkin (DG) method as an efficient, effective and compact numerical approach for numerical simulation of traffic flow problems on networks, with arbitrary high order accuracy. Road networks are modeled by graphs, composed of a finite number of roads that meet at junctions. On each road, a scalar conservation law describes the dynamics, while coupling conditions are specified at junctions to define flow separation or convergence at the points where roads meet. We incorporate such coupling conditions in the RK DG framework, and apply TVB limiter to the RK DG method to eliminate the oscillation on the network solutions. We showcase the proposed algorithm on several benchmark test cases from the literature, as well as several new challenging examples with rich solution structures.

2. **Ricky Ng (1.15-1.30 pm) - Tensor Product of Operator Systems**

**Abstract**

In this talk I will introduce operator system and the theory of their tensor products. We will see that certain nuclearity-related properties of  $C^*$ -algebras can be extended in the category of operator systems. We will also talk about their relation to the tensor products.

3. **Rahul Kumar (1.30-1.45 pm) - Control of Diffusion Phenomena on a Sphere**

**Abstract**

I will discuss the control of diffusion phenomena taking place on a time interval  $(0, T)$  and a circle using an actuator located on an open set (not necessarily connected) of circle. From a practical point of view, we will map circle to the interval  $0 \leq x < 1$  and impose periodic conditions at  $x = 0$  and  $x = 1$ . This will be motivation for controlling the diffusion phenomena on a Torus. I will also discuss my future plan i.e "controlling diffusion Phenomena on the sphere".

4. **Burcin Ozcan (1.45-2 pm) - Automated Extraction of Neurite Segments from Neuron Images**

**Abstract**

To better understand how neurons work and how different parts of neurons respond to different chemicals, identification of neurites has emerged as a significant problem in neuroscience. That's why, automating the reconstruction of neurons and labeling neurites is crucial. Nevertheless, the analysis and modeling of neuron images is particularly challenging. Since there are variations in shapes, variations in object sizes and noise from different sources. We consider the problem of automatically extracting and labeling all the neurite segments in a fluorescence microscopy neuron image. We propose a novel algorithm for automatically extracting and labeling the neurites in neuron image.

5. **Nicholas Maxwell (2.15-2.30 pm) - Gaussian-Polynomial Directional Representation Systems**

**Abstract**

Much recent effort in multiscale analysis has focused on the development of a class of directional representation systems (DRSs) for efficiently representing certain functions in 2D and 3D. Most notable examples of DRSs include curvelets and shearlets.

DRSs may be used to compress images and data appearing in a number of imaging techniques. Indeed, it is a major goal to use them to compress the imaging operators themselves.

In this talk I will present our development of a class of DRSs consisting purely of Gaussian polynomials (functions of the form  $f(x) = P(x) \exp(-x^T Ax)$ , for a symmetric positive-definite  $A$ , and a polynomial  $P$ ). Gaussian polynomials promise to achieve optimal uncertainty properties, and Gaussian polynomial DRSs exhibit a range of interesting algebraic properties.

6. **Eric Platt (2.30-2.45 pm) - Modeling nonlinear properties and fracture mechanics of Elasto-viscoplastic materials by use of an integrity property**

**Abstract**

Elastic materials can be modeled with the elasticity equation. Materials found in nature are not purely elastic. When under enough strain a material undergoes plastic deformation and eventually fracture. By use of an additional variable called integrity and it's coupled differential equation most of the properties can be described. With a numerical model the location and time of fracture can be predicted, and stress-strain curves can be generated. A synthetic material known as geof foam, with it's cyclic behavior can be modeled.

7. **Satish Pandey (2.45-3 pm) - Characterization of  $\mathcal{AN}$ -Operators**

**Abstract**

Operators that achieve absolutely their norm are said to be  $\mathcal{AN}$ -Operators. X. Carvajal and W. Neves studied these operators and proved important results concerning the characterization of the  $\mathcal{AN}$  operators. G. Ramesh claimed to obtain structure theorem for the class of  $\mathcal{AN}$ -Operators between complex, separable Hilbert spaces and characterized these operators but with some gaps. We dropped the separability of Hilbert spaces and have obtained the structure theorem of  $\mathcal{AN}$ -Operators between complex Hilbert spaces.

8. **Pei Yang (3-3.15 pm) - High order maximum principle preserving finite volume method for convection-diffusion equations**

**Abstract**

Maximum principle for the convection-diffusion equation

$$u_t + f(u)_x = A(u)_{xx}$$

is not satisfied when high-order finite volume scheme is applied to solve the problem. In this project, the maximum principle preserving (MPP) flux limiter is applied so that the numerical solution satisfies maximum principle while high-order accuracy is preserved at the same time. Effectiveness of the MPP limiter can be observed in numerical tests.

9. **Angelynn Alvarez (3.30-3.45 pm) - Positive Holomorphic Sectional Curvature on Projectivized Vector Bundles**

**Abstract**

In the world of complex geometry, there are very few known examples of metrics with positive holomorphic sectional curvature. In fact, there are more known results of metrics with negative curvature than positive curvature, thus, the search for manifolds with positive curvature is significant. In 1975, N. Hitchin proved that the projectivized vector bundle, the Hirzebruch surface,  $\mathbb{F}_n = \mathbb{P}(\mathcal{O}(n) \oplus \mathbb{C}), n \geq 0$  admits [Hodge] metrics of positive holomorphic sectional curvature. The topic in question is whether or not the positivity of the curvature is affected when the dimension of the fibers is increased, i.e. if

$$\mathbb{F}_{n_1, n_2, \dots, n_k} = \mathbb{P}(\mathcal{O}(n_1) \oplus \mathcal{O}(n_2) \oplus \dots \oplus \mathcal{O}(n_k) \oplus \mathbb{C}), \quad n_1, \dots, n_k \geq 0$$

still has positive holomorphic sectional curvature. We first discuss the case when the dimension is increased by one and then proceed to the general  $k$ -dimensional case.

10. **Akshay Agrawal (3.45-4 pm) - Plane Wave Discontinuous Galerkin Methods for the 2D Helmholtz Equation**

**Abstract**

Plane wave discontinuous Galerkin methods (PWDG) are a class of Trefftz-type methods for the spatial discretization of the boundary value problems for the Helmholtz operator  $-\Delta - \omega^2, \omega > 0$ . They include the so-called ultra weak formulation due to Cessant and Després. These methods use plane waves to approximate the solution to Helmholtz problem.

This presentation will go over the application of PWDG methods to solve 2D Helmholtz boundary value problem in convex domains. We will also discuss some difficulties faced in implementation of the PWDG methods and their solutions. Finally we will present some numerical results we have obtained and present ideas for current and future work.

11. **Manuel Lopez (4-4.15 pm) - Excentury: C++ to scripting languages**

**Abstract**

Scientific computing usually requires two aspects: an expensive simulation component, and an interactive exploration of the results. Low level programming languages such as C++ are very efficient for achieving the first component, whereas higher level packages such as Matlab and Mathematica, and increasingly python, are used for the latter. Even though it is possible to do so, there is a significant learning curve associated to extending the functionality of higher level languages by adding efficient C++ code for performing intensive computations.

In this talk, we will introduce Excentury, a set of libraries written in C++, that enables easy integration of C++ code into python and Matlab projects. This tool will be applied to a simple genetic network to study some of its dynamics.

12. **Danil Safin (4.15-4.30 pm) - NA**

**Abstract**

In this talk I will present a method for solving elliptic partial differential equations posed on hypersurfaces in  $R^N$ ,  $N=2,3$ . The method allows a surface to be given implicitly as a zero level of a level set function. A surface equation is extended to a narrow-band neighborhood of the surface. The resulting extended equation is a non-degenerate PDE and it is solved on a bulk mesh that is unaligned to the surface. An unfitted finite element method is used to discretize extended equations. I will also present our results for the error estimates for finite element solutions in the bulk domain and restricted to the surface. The analysis admits finite elements of a higher order and gives sufficient conditions for achieving the optimal convergence order in the energy norm. Finally, I will present several numerical examples to illustrate the properties of the method.

13. **Tristan Whalen (4.30-4.45 pm) - Classifying Leavitt path algebras using algebraic K-theory**

**Abstract**

Leavitt path algebras are algebras constructed from (directed) graphs, and may be thought of as algebraic versions of the graph  $C^*$ -algebras. In the theory of  $C^*$ -algebras, K-theory has proven to be a very useful and powerful tool for classification. In a similar way, attempts have been made to classify Leavitt path algebras using K-theory. It was shown by Efrén Ruiz and Mark Tomforde that certain simple unital Leavitt path algebras are classified up to Morita equivalence by their  $K_0$ -group and  $K_1$ -group, provided that the underlying field satisfies a certain property called "having no free quotients". Furthermore, Ruiz and Tomforde produced examples showing this classification can fail for Leavitt path algebras over fields without this property, such as the field of rational numbers. In this talk, we show that when the underlying field is a number field (i.e., a finite extension of the rational numbers), then the  $K_0$ -group and the  $K_6$ -group provide classification.