UTRGV Symposium on Mathematics and its Applications
A meeting in honor of Professor Emeritus Lokenath Debnath

The University of Texas-Rio Grande Valley
April 7, 2018

Presenters

Muhammad Bhatti	The University of Texas Rio Grande Valley
Jerry Bona	The University of Illinois at Chicago
Sudipto Roy Choudhury	University of Central Florida
Prabir Daripa	Texas A&M University
Biswanath Datta	Northern Illinois University
Jayanta Debnath	University of California San Francisco
Baofeng Feng	The University of Texas Rio Grande Valley
Norma Padron	Thomas Jefferson University
Elena Poletaeva	The University of Texas Rio Grande Valley
Daniel Riahi	The University of Texas Rio Grande Valley
Karen Yagdjian	The University of Texas Rio Grande Valley
Ahmed Zayed	DePaul University

Location

Emagc 1.302 (Wiener Lecture Hall)

Organizing committee

Dambaru Bhatta	dambaru.bhatta@utrgv.edu
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Program for Saturday, April 7, 2018

Location Emagc 1.302

07:30–08:30 *Breakfast* in Emagc 1.402

Chaired by ***Timothy Huber***

08:30–08:35 **Timothy Huber**
Welcome by the School Director of the School of Mathematical and Statistical Sciences

08:35–08:40 **Parwinder Grewal**
Welcome by the Executive Vice President for Research, Graduate Studies and New Program Development

08:40–08:45 **Lokenath Debnath**
Welcome by Professor Emeritus Lokenath Debnath

Chaired by ***Lokenath Debnath***

08:45–09:15 **Jerry Bona** (bona@math.uic.edu)
The University of Illinois at Chicago
"Ill-posedness results for nonlinear, dispersive wave equations"

09:15–09:45 **Biswanath Datta** (dattab@niu.edu)
Northern Illinois University
"Computational and optimization methods for quadratoc inverse eigenvalue problems arising in mechanical vibration and structural dynamics: Linking Mathematics to Industry"

09:45–10:15 **Ahmed Zayed** (azayed@math.depaul.edu)
DePaul University
"On the Existence and Uniqueness of fractional Fourier Series"

10:15–10:30 *Coffee break* in Emagc 1.402

Chaired by ***Eleftherios Gkioulekas***

10:30–11:00 **Jayanta Debnath** (jayanta.debnath@ucsf.edu)
University of California San Francisco
"Autophagy and Cancer Metastasis"

11:00–11:30 **Prabir Daripa** (daripa@math.tamu.edu)
Texas A&M University
"Challenges in mathematical modeling and computation of porous media flows for chemical enhanced oil recovery"

11:30–13:30 *Complimentary lunch at the University Dining Hall*, in honor of the participants, will be provided by the UTRGV School of Mathematical and Statistical Sciences.

CHAIRED BY ***Dambaru Bhatta***

13:30–14:00 **S. Roy Choudhury** (choudhur@cs.ucf.edu)
University of Central Florida
"Building Integrable NLPDE Hierarchies with Temporally AND Spatially Varying Coefficients"

14:00–14:30 **Daniel Riahi** (daniel.riahi@utrgv.edu)
University of Texas Rio Grande Valley
"Mathematical Modeling of Blood Flow in Elastic Arteries"

14:30–15:00 **Norma Padron** (Norma.padron@jefferson.edu)
Thomas Jefferson University
"Learning and applying mathematics in a complex world"

15:00–15:30 **Karen Yagdjian** (karen.yagdjian@utrgv.edu)
The University of Texas Rio Grande Valley
"A new integral transform approach to solving equations of the quantum field theory in the curved space-times."

15:30–15:45 *Coffee break* in EMAGC 1.402

CHAIRED BY ***Paul Bracken***

15:45–16:15 **Muhammad Bhatti** (Muhammad.bhatti@utrgv.edu)
The University of Texas Rio Grande Valley
"Application of fractional order differential equations in Physics and their solutions in fractional order B-Poly basis set"

16:15–16:45 **Baofeng Feng** (baofeng.feng@utrgv.edu)
The University of Texas Rio Grande Valley
"The KP-Toda hierarchy and Hirota's bilinear method"

16:45–17:15 **Elena Poletaeva** (elena.poletaeva@utrgv.edu)
The University of Texas Rio Grande Valley
"Finite W-algebras"

Abstracts

Muhammad Bhatti (Muhammad.bhatti@utrgv.edu)
The University of Texas Rio Grande Valley
Title: "Application of fractional order differential equations in Physics and their solutions in fractional order B-Poly basis set"
Abstract: An algorithm for approximating solutions to fractional-order differential equations in fractional polynomial basis will be presented. A finite generalized fractional-order basis set is obtained from the modified Bernstein Polynomials (B-polys), where α is the fractional-order of B-polys. The algorithm determines the desired solution in terms of continuous finite number of generalized fractional polynomials in a closed interval and makes use of Galerkin method to calculate the unknown expansion coefficients for constructing the approximate solution to the fractional differential equations. Each term in a differential equation is converted into matrix form and the final matrix problem is inverted to construct a solution of the fractional differential equations. However, the accuracy and the efficiency of the algorithm rely on the size of the set of B-polys and its fractional order. Furthermore, a recursive definition for generating fractional B-polys and the analytic formulism for calculating fractional derivatives are presented. The current algorithm is applied to solve the fractional Schrodinger equation, fractional harmonic oscillator problems plus a number of linear and non-linear fractional differential equations. An excellent agreement is obtained between desired and exact solutions. Furthermore, the current algorithm has great potential to be implemented in other disciplines, when there are no exact solutions available to the fractional differential equations.

Jerry Bona (bona@math.uic.edu)
The University of Illinois at Chicago
Title: "Ill-posedness results for nonlinear, dispersive wave equations"
Abstract: The discussion will deal with both deep water and shallow water models for surface water waves. In the shallow water situation, new results showing that some well known models are ill-posed are brought forward. In the deep water condition, a new model is derived using standard Hamiltonian expansion. Despite its Hamiltonian structure, this one appears also to be ill-posed. This latter result is surprising and begs for an explanation.

S. Roy Choudhury (choudhur@cs.ucf.edu)
University of Central Florida
Title: "Building Integrable NLPDE Hierarchies with Temporally AND Spatially Varying Coefficients"
Abstract: In the present talk, we present two techniques, based on generalized Lax Pairs and similarity transformation methods, to derive generalizations of various integrable (in the Lax sense) NLPDE hierarchies. As illustrative examples, we consider a generalized NLS equation, as well as a very recent non-local and PT-symmetric NLS equation. We demonstrate that the techniques yield integrable equations with both time- AND space-dependent coefficients, and are thus more general than cases with only temporally varying coefficients treated earlier via the Painlevé Test and the use of Bell polynomials. Motivated by this, we develop a generalization of the Lie-algebraic Estabrook-Wahlquist Method to derive such hierarchies systematically. The methods have been applied to generalize some well-known integrable

NLPDE hierarchies, and are currently being applied to others as well. Deriving integrability properties, such as Backlund Transformations, Hirota operators, Tau functions, soliton solutions and so on, of these generalized hierarchies remains largely open to investigation

Prabir Daripa (daripa@math.tamu.edu)
Texas A&M University
Title: "Challenges in mathematical modeling and computation of porous media flows for chemical enhanced oil recovery"
Abstract: Chemical enhanced oil recovery involves fluid flows of simple and/or complex fluids with chemical components through heterogeneous porous media. We will discuss challenges in modeling such flows and discuss some models at various levels of approximation and efficient ways to compute some of such flows. In particular, we will present our recently developed n-component global pressure formulation based nonlinearly coupled system of PDEs. We will briefly discuss our recently developed Discontinuous Finite Element Method and the Modified Method of Characteristics (DFEM-MMOC) based hybrid method for solving such classes of PDEs [1]. Convergence and numerical results wil be presented. Fluid dynamical aspects such as dispersive and diffusive stabilization of viscous instabilities [2] may be discussed. The speaker will also touch upon some mathematical, physical and computational problems which are forward looking and could be future topics of Ph.D. thesis and collaboration.

This work has been possible due to financial support from NPRP grant 08-777-1-141 through Qatar National Research Fund and the U.S. National Science Foundation grant DMS-1522782.

References

(1) P. Daripa and S. Dutta (2017). Modeling and simulation of surfactant-polymer flooding using a new hybrid method. *Journal of Computational Physics*, **335**, 249-282.
(2) P. Daripa and C. Gin (2016). Studies on dispersive stabilization of porous media flows. *Physics of Fluids*, **28(8)**, 82105.

Biswanath Datta (dattab@niu.edu)
Northern Illinois University
Title: "Computational and optimization methods for quadratoc inverse eigenvalue problems arising in mechanical vibration and structural dynamics: Linking Mathematics to Industry."
Abstract: The Quadratic Eigenvalue Problem is to find eigenvalues and eigenvectors a quadratic matrix pencil of the form $P(\lambda) = M\lambda^2 + C\lambda + K$, where the matrices M, C, and K are square matrices. Unfortunately, The problem has not been widely studied because of the intrinsic dificulties with solving the problem in a numerically effective way. Indeed, the state-of-the-art computational techniques are capable of computing only a few extremal eigenvalues and eigenvectors, especially if the matrices are large and sparse, which is often the case in practical applications. The inverse quadratic eigenvalue problem, on the other hand, refers to constructing the matrices M, C, and K, given the complete or partial spectrum and the associated eigenvectors. The inverse quadratic eigenvalue problem is equally important and arises in a wide variety of engineering applications, including mechanical vibrations, aerospace engineering, design of space structures, structural dynamics, etc. Of special practical importance is to construct the coefficient matrices from the knowledge of only partial spectrum and the associated eigenvectors. The greatest computational challenge is to solve the partial quadratic inverse eigenvalue problem using the small number of eigenvalues and eigenvectors

which are all that are computable using the state-of-the-art techniques. Furthermore, computational techniques must be able to take advantage of the exploitable physical properties, such as the symmetry, positive definiteness, sparsity, etc., which are computational assets for solution of large and sparse problems.

This talk will deal with two special quadratic inverse eigenvalue problems that arise in mechanical vibration and structural dynamics. The first one, Quadratic Partial Eigenvalue Assignment Problem(QPEVAP), arises in controlling dangerous vibrations in mechanical structures. Mathematically, the problem is to find two control feedback matrices such that a small amount of the eigenvalues of the associated quadratic eigenvalue problem, which are responsible for dangerous vibrations, are reassigned to suitably chosen ones while keeping the remaining large number of eigenvalues and eigenvectors unchanged. Additionally, for robust and economic control design, these feedback matrices must be found in such a way that they have the norms as small as possible and the condition number of the modified quadratic inverse problem is minimized. These considerations give rise to two nonlinear unconstrained optimization problems, known respectively, as Robust Quadratic Partial Eigenvalue Assignment Problem (RQPEVAP) and Minimum Norm Quadratic Partial Eigenvalue Assignment Problem (MNQPEVAP). The other one, the Finite Element Model Updating Problem (FEMUP), arising in the design and analysis of structural dynamics, refers to updating an analytical finite element model so that a set of measured eigenvalues and eigenvectors from a real-life structure are reproduced and the physical and structural properties of the original model are preserved. A properly updated model can be used in confidence for future designs and constructions. Another major application of FEMUP is the damage detections in structures. Solution of FEMUP also give rises to several constrained nonlinear optimization problems. I will give an overview of the recent developments on computational methods for these difficult nonlinear optimization problems and discuss directions of future research with some open problems for future research. The talk is interdisciplinary in nature and will be of interests to computational and applied mathematicians, and control and vibration engineers and optimization experts.

Jayanta Debnath (jayanta.debnath@ucsf.edu)
University of California San Francisco
Title: "Autophagy and Cancer Metastasis"
Abstract: Metastasis remains the principal cause of cancer mortality. Autophagy, a conserved pathway of nutrient recycling and metabolic adaptation, has been proposed as a potential therapeutic target in metastasis, with several studies suggesting that autophagy promotes the metastatic properties of tumor cells. I will discuss the dual and highly stage-specific roles for the autophagy pathway during metastatic progression in vivo and how to best exploit this pathway in the clinical oncology setting.

Baofeng Feng (baofeng.feng@utrgv.edu)
The University of Texas Rio Grande Valley
Title: "The KP-Toda hierarchy and Hirota's bilinear method"
Abstract: In this talk, we will review recent development on Hirota's bilinear method. We will introduce a KP-Toda hierarchy and its general solution, the so-called tau functions. A set of bilinear equations satisfied by these tau functions will be presented. Then, we will show many well-known soliton equation and their multi-soliton solutions, such as the KdV

equation, the modified-KdV equation, the sine-Gordon equation, the nonlinear Schrödinger (NLS) equation and the Bossinesq equation can be reduced from these bilinear equations. Furthermore, we will show the Camassa-Holm (CH) and Degasperis-Procesi (DP) equations, as well as their soliton solutions, can also be reduced from a generalized KP-Toda hierarchy.

Another important application of Hirota's bilinear method is the integrable discretization of soliton equations. If time permits, by taking the sine-Gordon equation and the Hunter-Saxton equation as examples, we will show how the semi-discrete and fully discrete analogues of soliton equation can be constructed from the Bäcklund transform of the KP-Toda hierarchy.

Norma Padron (Norma.padron@jefferson.edu)
Thomas Jefferson University
Title: "Learning and applying mathematics in a complex world"
Abstract: Employers are increasingly demanding skills that rely on a thorough understanding of mathematics and data. According to the Bureau of Labor Statistics (BLS), the projected percent change in employment from 2016 to 2026 for those with a mathematics degree is 33 percent. The average growth rate for all occupations is 7 percent. Making sure that the tremendous opportunity of improving access and quality of mathematics education for students is not missed, will not only result in better employment opportunities, but in bringing an urgently needed diversity of experiences and backgrounds to various fields of practice in which women and minorities, remain under-represented. In this brief presentation I will discuss some of the challenges and opportunities in the health care sector-with broad implications-to improve the workforce capacity by improving mathematics and data skills.

Elena Poletaeva (elena.poletaeva@utrgv.edu)
The University of Texas Rio Grande Valley
Title: "Finite W-algebras"
Abstract: Finite W-algebras are certain associative algebras attached to a pair $(\mathfrak{g}, e)$, where $\mathfrak{g}$ is a complex semi-simple Lie algebra and $e \in \mathfrak{g}$ is a nilpotent element. They are generalizations of the universal enveloping algebra $U(\mathfrak{g})$ and have many interesting applications. They have been extensively studied by mathematicians and physicists. It is a result of B. Kostant that for a regular nilpotent element, the finite W-algebra coincides with the center of $U(\mathfrak{g})$. We shall present some basic facts about finite W-algebras and our recent results on finite W-algebras for Lie superalgebras.

Daniel Riahi (daniel.riahi@utrgv.edu)
University of Texas Rio Grande Valley
Title: "Mathematical Modeling of Blood Flow in Elastic Arteries"
Abstract: In this lecture we first review mathematical modeling that have been carried out recently for steady and unsteady two-phase arterial blood flow systems with stenosis based on the experimentally generated data but with focus on blood pressure and flow inside the arteries. Next, we consider the relevant governing equations for the motion of the surface of the elastic and deformable arteries and in the presence of stenosis. We determine solutions for the displacement components of the elastic arterial motion and present the results for the effects of elastic stresses, hematocrits, wall stiffness, wall thickness, volume flow rate, blood

pressure and other forces acting on the artery system. We explain several notable effects such as those by the elastic artery surface on the blood pressure in the stenosis zone, etc. and how such effects can improve or worsen the patience's health.

Karen Yagdjian (karen.yagdjian@utrgv.edu)
The University of Texas Rio Grande Valley
Title: "A new integral transform approach to solving equations of the quantum field theory in the curved space-times"
Abstract: In this talk we will present the integral transform that allows us to construct solutions of the hyperbolic partial differential equation with variable coefficients via solutions of a simpler equation. This transform was suggested by the author in the case when the last equation is a wave equation. Then it was used to investigate several well-known equations such as generalized Tricomi equation, the Klein-Gordon equation of the quantum field theory in the de Sitter and Einstein-de Sitter space-times of the expanding universe. In particular it was shown that a field with the mass $\sqrt{2}$ is *huygensian*. Moreover, the numbers $\sqrt{2}, 0$ are the only values of the mass such that equation obeys an *incomplete Huygens' Principle*. Then, it was shown that in the de Sitter space-time the existence of two different scalar fields (with mass 0 and $\sqrt{2}$), which obey the *incomplete Huygens' principle*, is equivalent to the condition that the spatial dimension of the physical world is 3. In fact, Paul Ehrenfest in 1917 addressed the question: "Why has our space just three dimensions?". In this talk a special attention will be also given to the global in time existence of self-interacting scalar field in the de Sitter universe and to the Higuchi bound of the quantum field theory and equations with the Higgs potential. The talk is based on the contents of following publications:
(1) K.Yagdjian; A. Galstian: *Comm. Math. Phys.* **285** (2009), no. 1, 293-344.
(2) K.Yagdjian: *Comm. Partial Differential Equations* **37** (2012), no. 3, 447-478.
(3) K.Yagdjian: *J. Math. Phys.* **54** (2013), no. 9, 091503, 18 pp.
(4) K.Yagdjian: *J. Differential Equations* **259** (2015), no. 11, 5927-5981.
(5) K.Yagdjian: *Math. Nachr.* **288** (2015), no. 17-18, 2129-2152.
(6) A. Galstian; K.Yagdjian: *Nonlinear Anal. Real World Appl.* **34** (2017), 110-139.

Ahmed Zayed (azayed@math.depaul.edu)
DePaul University
Title: "On the Existence and Uniqueness of fractional Fourier Series"
Abstract: The existence and uniqueness of Foureir series have been extensively studied for over a century. More recently the notion of fractional Fourier series has been introduced and it appears to have some applications in Brownian motions. In this talk we shall discuss the existence and uniqueness of such series.