Abstracts

Mufid Abudiab (Mufid.abudiab@tamucc.edu)
Texas A&M University-Corpus Christi
Title: "The Lower Upper Solutions Method: Its Power and Limitations"
Abstract: A brief history of the method of upper lower solutions and its wide application in the theory of boundary value problems will be displayed. Special attention will be given to the relations of upper lower solutions method with other methods (degree theory, variational methods, iterative methods, etc.) of nonlinear analysis. Finally, an extension of the classical lower-upper solution technique to non-linear non-homogeneous elliptic systems without the assumption of quasi-monotonicity under non-linear boundary conditions will be presented with an application in biology and medical science.

Reza Ahangar (kfrra00@tamuk.edu)
Texas A&M University-Kingsville
Title: "Dynamic Behavior of Perturbed Nonlinear Operator Differential Equations"
Abstract: A nonlinear operator dynamical system

$$\begin{cases} y'(t) = f(t, y(t), G[y](t)), & t \geq t_0 \\ y(t) = \phi(t), & t < t_0 \end{cases}, \tag{1}$$

has been studied extensively.

The operator G from a domain D into the space of measurable functions Y is called a non-anticipating operator if the past information is independent from the future outputs. We will use the solution to the operator differential equation

$$y'(t) = A(t)y(t) + G[y](t). \tag{2}$$

To analyze the solution of the perturbed operator differential equation

$$y'(t) = A(t)y(t) + G[y](t) + \xi(t) \tag{3}$$

which is generated by a perturbation ξ. When this perturbation is from a measurable space then the existence and uniqueness of the solution to the operator differential equation

$$y'(t) = A(t)y(t) + G[y](t) + g(t, y(t)) \tag{4}$$

will be studied. Finally, we use the nonlinear variation of parameters for non-anticipating operator differential equations to study the stability and asymptotic behavior of the equilibrium solution.

Sergey Belov (belov@rice.edu)
Rice University
Title: "Riemann-Hilbert approach to the semiclassical focusing Nonlinear Schrodinger equation."
Abstract: In this talk we will discuss a one dimensional focusing NLS with cubic nonlinearity in the semiclassical limit. For this completely integrable system, the inverse scattering for the underlying linear Zakharov-Shabat system could be done using the Riemann-Hilbert problem (RHP) approach. We will discuss parameter dependence of scalar RHPs and generalize the result for a wider class of general scalar RHPs.

Joshua Benavidez (jbenavidez@islander.tamucc.edu)
Texas A&M University-Corpus Christi
Title: "Use of the Routh Hurwitz method to study the stability of a system of differential equations"
Abstract: In this talk, we will share with the audience certain conditions that are necessary to achieve the stability in a system of differential equations and its variations. In particular, we will investigate the Routh Hurwitz criteria for stability/asymptotic stability as well as the role of the eigenvalue method in determining stability/asymptotic stability. Our work will cover time dependent systems as well as non-time dependent systems to see a difference.
This is joint work with **Mufid Abudiab**, and **Christina Martinez**

Dambaru Bhatta (bhattad@utpa.edu)
University of Texas-Pan American
Title: "Derivation of the Landau coefficients for convective flow in a mushy layer"
Abstract: Here we derive the Landau coefficients for the convective flow in a horizontal mushy layer formed during the solidification of binary alloys. The mushy layer is treated as porous media in presence of inertial terms in the momentum-Darcy equation. We derive the linear, adjoint and first-orders systems and use these solutions to obtain the Landau coefficients. Our future aim is to compute these coefficients numerically to see if there is a fast or slow transition to turbulence.
This is joint work with **Daniel Riahi**.

Paul Bracken (bracken@panam.edu)
University of Texas-Pan American
Title: "Deformation of Surfaces in Three-Dimensional Space Induced by Means of Various Integrable Systems"
Abstract: The correspondence between different versions of the Gauss-Weingarten equation is investigated. The compatibility condition for one version of the Gauss-Weingarten equation gives the Gauss-Mainardi-Codazzi system. A deformation of the surface is postulated which takes the same form as the original system but contains an evolution parameter. The compatibility condition of this new augmented system gives the deformed Gauss-Mainardi-Codazzi system. A Lax representation in terms of a spectral parameter associated with the deformed system is established. Several important examples of integrable systems based on the deformed system obtained as reductions are presented.

Martina Bukac (martina@math.uh.edu)
University of Houston
Title: "Thin shell model capturing longitudinal displacement observed in human arteries"
Abstract: We study blood flow in medium-to-large arteries, modeled by the Navier-Stokes equations for an incompressible viscous fluid coupled with equations describing the mechanics of the arterial walls. Considering recent *in vivo* studies that identified significant viscoelastic wall properties and longitudinal wall displacement, we model arterial walls using the linearly viscoelastic Koiter shell model involving both radial and longitudinal displacement. The

numerical scheme we use is an extension of the kinematically-coupled scheme described in [1]. Our algorithm is tested using physiological parameters. Results show comparable longitudinal and radial displacements, implying that longitudinal displacement cannot be neglected.

(1) G. Guidoboni, R. Glowinski, N. Cavallini, and S. Canic (2009): "Stable loosely-coupled-type algorithm for fluid-structure interaction in blood flow", *J. Comput. Phys.*, **228(18)**: 6916-6937.

Sam Cavazos (samcavazos@rocketmail.com)
University of Texas-Pan American

Title: "Modeling and computation of blood flow resistance of an atherosclerotic artery with multiple stenoses"

Abstract: Diseases in the blood vessels and in the heart, such as heart attack and stroke, are the major causes of mortality worldwide. The underlying cause for these events is the formation of lesions, known as atherosclerosis. These lesions and plaques can grow and occlude the artery and hence prevent blood supply to the distal bed. We derive the governing non-axisymmetric equations and the boundary conditions for the mathematical models of the flow of blood as a Newtonian incompressible fluid flow in the artery and carry out analysis. We derive expressions for pressure drop, pressure gradient, shear stress, impedance, and central axial velocity. We have developed the computer program using numerical methods to estimate quantitative effects of various parameters involved on the results of the analysis and have investigated the computed results for the dependent variables for realistic parameter regimes for the case of human arteries and find the effect and the roles played by the stenoses on the blood flow. The results will assist us to understand the blood flow through the blood vessel with multiple stenoses.

This is a joint work with **Ranadhir Roy** and **Daniel N. Riahi**.

Goong Chen (gchen@math.tamu.edu)
Texas A&M University

Title: "Computation and visualization of the nonlinear Schrödinger equation in nonlinear optics by OpenFOAM"

Abstract: A large number of optical phenomena are modeled as an initial-boundary value problem governed by the nonlinear Schrödinger equation. In this talk, we will show numerical computational results for several nonlinear optical dynamic processes containing various forms of nonlinearities. The numerical scheme is based on a parabolic marching in time and a finite-volume method using adapted from the fluid-dynamics software OpenFOAM.

This is joint work with **Milivoj Belic** and **Alexey Sergeev** of Texas A&M University-Qatar.

Sayantan Das (sdas@broncs.utpa.edu)
University of Texas-Pan American

Title: "On temporal instability of electrically forced axisymmetric jets with variable applied field and nonzero basic state velocity"

Abstract: This paper considers the problem of instability of electrically forced axisymmetric jets with respect to temporally growing disturbances. We derive a dispersion relation based on the relevant approximated versions of the equations of the electro-hydrodynamics for an electrically forced jet flow. For temporal instability, we find in the realistic cases of the non-zero basic state velocity that the growth rate of the unstable mode is unaffected by the value of the basic state velocity. However, the non-zero value of the basic state velocity affects significantly the period of the unstable mode in the sense that it decreases the period, and the rate of increase of the frequency with respect to the axial wave number increases with the basic state velocity. It is also observed from numerical investigations that there are two modes of instability for small values of the wavenumber.

This is joint work with **Dambaru Bhatta** and **Daniel N. Riahi**

Lokenath Debnath (debnathl@utpa.edu)
University of Texas-Pan American
Title: "Euler Equations and the KdV equation for the Gravity-Capillary Waves"
Abstract: The Euler Equations and the origin of singularities will be discussed. The derivation of the KdV equation for gravity-capillary gravity waves will be presented with different kinds of solitary waves.

Anahit Galstyan (agalstyan@utpa.edu)
University of Texas-Pan American
Title: "Hyperbolic Equations in Einstein-de Sitter spacetime"
Abstract: In this talk we investigate initial value problem for the wave equation in the Einstein-de Sitter spacetime and give the explicit representation formulas for the solutions. The equation is strictly hyperbolic in the domain with positive time. On the initial hypersurface its coefficients have singularities that make difficult the study of the initial value problem. In particular, one cannot anticipate the well-posedness in the Cauchy problem for the wave equation in the Einstein-de Sitter spacetime. The initial conditions must be modified to the so-called weighted initial conditions in order to adjust them to the equation. We also show the L_p-L_q estimates for the solutions.

This is a joint work with **Tamotu Kinoshita** (University of Tsukuba, Japan) and **Karen Yagdjian** (UTPA).

Eleftherios Gkioulekas (gkioulekase@utpa.edu)
University of Texas-Pan American
Title: "The effect of asymmetric large-scale dissipation on energy and potential enstrophy injection in two-layer quasi-geostrophic turbulence"
Abstract: In the Nastrom-Gage spectrum of atmospheric turbulence we observe a k^{-3} energy spectrum that transitions into a $k^{-5/3}$ spectrum, with increasing wavenumber k. The transition occurs near a transition wavenumber k_t, located near the Rossby deformation wavenumber k_R. The Tung-Orlando theory interprets this spectrum as a double downscale cascade of potential enstrophy and energy, from large scales to small scales, in which the downscale

potential enstrophy cascade coexists with the downscale energy cascade over the same length-scale range. We show that, in a temperature forced two-layer quasi-geostrophic model, the rates with which potential enstrophy and energy are injected place the transition wavenumber k_t near k_R, as long as most potential enstrophy and energy cascade to small scales. We also show that, contrary to what occurs in two-dimensional turbulence, the asymmetric Ekman term tends to intensify the energy flux in the subleading downscale energy cascade, and it may increase or decrease the flux of the downscale potential enstrophy cascade, depending on the distribution of total energy between kinetic and potential energy for the forcing range wavenumbers. Using a random gaussian forcing model, we also show that suppressing the bottom layer forcing term decreases the ratio η/ε of injected potential enstrophy over injected energy, thereby tending to decrease k_t further. Based on these results, we argue that the Tung-Orlando theory can account for the approximate coincidence between k_t and k_R.

This is in part joint work with **Ka-Kit Tung**.

Yuliya Gorb (gorb@math.uh.edu)
University of Houston
Title: "Blow up phenomena in high contrast composites"
Abstract: In this talk we present results of our recent study of blow up phenomena in high contrast two-phase dispersed composites described by PDEs with rough coefficients. We explore both linear and non-linear formulations. The gradients of solutions to such problems exhibit singular behavior – blow up – that can be captured by constructing and analyzing an approximate discrete system to the original continuum problem.

Luan Hoang (luan.hoang@ttu.edu)
Texas Tech University
Title: "Dynamics and Stabilities of Generalized Forchheimer Flows in Porous Media"
Abstract: We study generalized Forchheimer equations for slightly compressible fluids in porous media subjected to the volume flux boundary condition. We derive estimates for the pressure, its gradient and time derivative in terms of the time-dependent boundary data. For the stability, we establish the continuous dependence of the pressure and pressure gradient on the boundary data and coefficients of the Forchheimer polynomials in the momentum equation. In particular, we show the asymptotic dependence for the shifted solution on the asymptotic behavior of the boundary data. In order to improve estimates of various types, we derive suitable inequalities of Poincare-Sobolev and Gronwall types, as well as uniform Gronwall-type inequalities deduced from a system of coupled differential inequalities.

Natali Hritonenko (nahritonenko@pvamu.edu)
Prairie View A&M University
Title: "Optimal Control of PDE and Integral Equations with Delay in Operations Research and Environmental Sciences"
Abstract: PDEs and integral equations with delay are used to model various phenomena in the economic growth theory, operations research, management sciences, environmental protection, life sciences, population biology, and other areas. The delays reflect the age

of individuals to be harvested or the lifetime of obsolete equipment to be replaced due to technological innovations. Optimal control in such models is introduced to find the optimal investment in abatement and adaptation or to estimate the harvesting age or to maximize the production profit. Discrete models of equipment replacement in Operations Research can be also converted to the continuous models with delay. This transformation opens new ways to investigate the discrete models and lead to new results. Optimal control problems in integral-differential settings will be presented and methods of their investigation will be discussed.

Tim Huber (hubertj@utpa.edu)
University of Texas-Pan American
Title: "Applications of a differential system to quintic Eisenstein series"
Abstract: The Rogers-Ramanujan continued fraction is a generalization of the continued fraction expansion for the golden ratio. In this talk, we will derive a variety of identities that connect the Rogers-Ramanujan continued fraction to twisted Eisenstein series on the subgroup $\Gamma_0(5)$ of the full modular group. We will use a differential system satisfied by generalizations of the Eisenstein series to prove a variety of identities satisfied by the Rogers-Ramanujan continued fraction. A more general method for deriving similar identities for modular forms of higher level will be discussed as time permits.

Ranis N. Ibragimov (Ranis.Ibragimov@utb.edu)
University of Texas at Brownsville
Title: "Integration by quadratures of nonlinear Euler and Navier-Stokes equations modeling atmospheric motion"
Abstract: This presentation provides audience with the mathematical modeling of non linear largescale atmospheric motion around the rotating Earth. The inquiry is motivated by dynamically significant Coriolis forces in meteorology and oceanographic applications such as climate variability models and general atmospheric circulation model. In almost all oceanographic applications, e.g., meteorology, the effects of rotation and the spherical shape of the Earth cannot be ignored. For the most large-scale world phenomena, atmospheric motions exhibit quite different wave phenomena than non rotating atmospheric patterns.

The model uses the two-dimensional Euler and Navier-Stokes equations on a spherical surface and serves as a simple mathematical description of a general atmospheric circulation caused by the difference in temperature between the equator and the poles. The model is also complicated by a superimposed particular stationary flow which, under the assumption of no friction and a distribution of temperature dependent only upon latitude, models the zonal west-to-east flows in the upper atmosphere between the Ferrel and Polar cells. Owing to the Coriolis effects generated by the pseudoforces, the latter achievable meteorological flows rotating around the poles correspond to the asymptotical stable flows that are being translated along the equatorial plane.

The presentation addresses new exact stationary and non-stationary solutions to the nonlinear nonsteady model. The exact solutions in terms of elementary functions are found as

invariant solutions of the governing equations by means of integration by quadratures of the Euler and Navier-Stokes nonlinear equations in spherical angles using Lie group methods.

This presentation is based partially on the following two previous publications:

(1) Ibragimov, R.N., Pelinovsky, D.E. (2009): "Incompressible viscous flows in a thin spherical shell", *Journal of Mathematical Fluid Mechanics*, **11**, 60-90
(2) Ibragimov, R.N., Pelinovsky, D.E. (2010): "Effects of rotation on stability of viscous flows on a spherical surface", *Physics of Fluids*, **22**, 126601

Katarina Jegdic (JegdicK@uhd.edu)
University of Houston-Downtown
Title: "A free boundary problem for two-dimensional gas dynamics equations"
Abstract: We consider a Riemann problem for two-dimensional isentropic gas dynamics equations that results in interaction of a shock with a wedge. We write the problem in self-similar coordinates and we obtain a mixed type system and a free boundary problem where the location of the free boundary is the reflected shock. Further, we rewrite this problem using a second order equation for density and two "transport" equations for velocities. We prove existence of a solution to the free boundary problem by fixing the position of the boundary, solving the fixed boundary problem and updating the position of the boundary. We show that this mapping on the space of admissible boundaries has a fixed point. Proof of existence of a solution to the fixed boundary problem involves fixed point arguments and theory of second order elliptic equations with mixed boundary conditions.

Mikhail Kovalyov (mkovalyo@ualberta.ca)
University of Alberta, Canada
Title: "Modeling rogue waves by means of solutions of KP."
Abstract: The rogue waves are the waves that appear seemingly out of nowhere, destroy ship, cause a lot of damage. Until recently they were considered to be an object of fiction, eyewitness accounts were always dismissed as unscientific evidence. Recently however, they became very popular with numerous "models" popping up almost regularly; none seems to provide an adequate description comparable with eyewitness accounts. An example of such a wave is provided at http://surf.transworld.net/1000076370/features/was-kerby-brown-on-today-show-after-riding-monster-wave/. Without any hope of success we decided to compare the wave shown in the video to an appropriate solution of KP, the result exceeded all expectations. Not only the solutions provide a reasonable prediction of the shape of the wave, the also explain why the waves often comes with several big splashes.

Ruediger Landes (rlandes@ou.edu)
University of Oklahoma
Title: "Stable and unstable initial configuration in the theory of wavefronts"
Abstract: We are discussing stable and unstable initial values of certain parabolic nonlinear boundary problems, which have been introduced about a decade ago by W. Marquardt from the RWTH in Aachen, to model the phase transition of two different states of boiling liquids.

We compare our results to those of the classical work by Aranson-Weinberger, discusses the phase transitions for nonlinear parabolic equations with fixed boundary data.

Runchang Lin (rlin@tamiu.edu)
Texas A&M International University
Title: "A balanced finite element method for singularly perturbed reaction-diffusion problems"
Abstract: In this talk, a balanced and stronger norm is introduced for singularly perturbed reaction-diffusion problems. A mixed finite element method is constructed whose solution is quasi-optimal in this new norm. Error estimates and numerical results are presented.

This is joint work with Dr. Martin Stynes, National University of Ireland, Cork, Ireland.

George Omel'yanov (omel@hades.mat.uson.mx)
University of Sonora, Mexico
Title: "Interaction of singularities and the uniqueness problem for quasilinear hyperbolic systems"
Abstract: We consider jump-type initial data for strictly hyperbolic quasilinear system of conservation laws in one-space dimension. Suppose that the initial jump is associated formally with a shock wave. The aim of the talk is the consideration of sufficient stability conditions for this problem in the case of arbitrary jump amplitude.

Tuoc Van Phan (phan@math.utk.edu)
University of Tennessee
Title: "Normal form for the symmetry-breaking bifurcation in the nonlinear Schrodinger equation"
Abstract: We derive and justify a normal form reduction of the nonlinear Schrödinger equation for a general pitchfork bifurcation of the symmetric bound state that occurs in a double-well symmetric potential. We prove persistence of normal form dynamics for both supercritical and subcritical pitchfork bifurcations in the time-dependent solutions of the nonlinear Schrödinger equation over long but finite time intervals.

This is the joint work with **D.E. Pelinovsky.**

Virgil Pierce (virgilpierce@gmail.com)
University of Texas-Pan American
Title: "Differential equations for the enumeration of polygonal dissections"
Abstract: The Euler polygon division problem poses the question: In how many ways may a $(n+2)$-sided polygon be divided into triangles whose sides are the sides and diagonals of the original polygon? The solution is given by the Catalan numbers, which also solve such enumerative problems as: the number of Dyck paths starting and ending at the x-axis, the number of ways a $2n$-sided polygon can be glued together to give a sphere, and many others (perhaps most interestingly it has recently been shown that the Catalan numbers give the number of non-interacting solitary wave solutions to a 2D shallow water wave equation). We will consider such generalizations as: In how many ways may a $(2n+2)$-sided polygon be divided into squares? or In how many ways may a sphere or torus may be divided into

pentagons? Our method of solving these problems is to give non-linear, non-homogeneous differential equations which govern the generating function of the solutions, and then to derive explicit solutions of these equations.

Ranadhir Roy (rroy@utpa.edu)
University of Texas-Pan American
Title: "Investigation of Characteristic of Chyme Flow during Gastrointestinal Endoscopy using Different Mathematical Models"
Abstract: Intestinal infection has become a common disease in human and endoscopy can be a powerful means in diagnosis of intestinal illnesses. Mathematical models are developed to find the effect of an inserted endoscope on the flow of chyme in the small intestine and assumed the chyme flow as a Newtonian incompressible fluid flow, under an axisymmetric condition, in a cylindrical annulus between the small intestine and the endoscope. The peristaltic flow of chyme is modeled (i) by assuming that the peristaltic rush wave is a non-periodic mode composing of two sinusoidal waves of different wavelengths, which propagate at the same speed along the outer boundary of the tube and another (ii) by assuming that that the peristaltic rush wave is a non-periodic mode composing of one sinusoidal wave. For the realistic values of the parameters for these two flow cases, we determine the expressions for the leading order pressure drop, the pressure, the axial velocity, and the frictional forces at the boundaries, and evaluated the roles played by these quantities in the investigated flow systems. The presence of two-wave peristaltic mode was found to facilitate less positive (adverse) pressure gradient and less forces by the boundaries on the flow of chyme. The results are presented, and discussed for the cases and conditions under which pressure, pressure drop in the chyme flow can be positive or negative and the forces can be acted either by the intestine or endoscope on the flow or vice-versa. We compared with the corresponding ones that are done by other available investigations.

This is joint work with **Fabiola Rios** and **Daniel N. Riahi**.

José Santiago Cruz Bañuelos (jose.santiago.cruz@udem.edu.mx)
Universidad de Monterrey
Title: "One solution of the Duffing Equation by using the Finite Element Method"
Abstract: The method of finite elements is used to solve the equation of forced Duffing, this generates a system of equations nonlinear, the convergence of the solution depends on the method used in this system of equations, it was used the direct iteraccin and the method of Newton-Raphson.

Chris Trombley (ctrombley@islander.tamucc.edu)
Texas A&M University-Corpus Christi
Title: "Exact Differential Equations in $\mathbb{R}^n$"
Abstract: An exact differential equation describes a conservative vector field. Exact differential equations of two variables can be solved using a certain method, which we will call the exact method. In this paper, we will generalize exact differential equations and present necessary and sufficient conditions for exactness in $\mathbb{R}^n$. We will apply the conditions of exactness

to systems of differential equations, and look at how to extend the exact method in order to solve them. Finally, we will look at the application of exactness to gravitational and electric fields.

This is joint work with **Mufid Abudiab**, **Zulema Cervantes**, and **Andrew Hornbuckle**

Ram Verma (verma99@msn.com)
Texas A&M University - Kingsville
Title: "Generalized Frameworks for First-Order Evolution Inclusions Based on Yosida Approximations"
Abstract: First, general frameworks for the first-order evolution inclusions are developed based on the A-maximal relaxed menotonicity and then using the Yosida approximation the solvability of a general class of first-order nonlinear evolution inclusions is investigated. The role the A-maximal relaxed monotonicity is significant in the sense that it not only empowers the first-order nonlinear evolution inclusions but also generalizes the existing Yosida approximations and its characterizations in the current literature.

Karen Yagdjian (yagdjian@utpa.edu)
University of Texas-Pan American
Title: "Fundamental Solutions for Hyperbolic Operators with Variable Coefficients"
Abstract: In this talk we describe a novel method to construct fundamental solutions for operators with variable coefficients. That method was introduced by the author to study the Tricomi-type equation. More precisely, a new integral operator is suggested which transforms the family of the fundamental solutions of the Cauchy problem for the equation with the constant coefficients to the fundamental solutions for the operators with variable coefficients.

Maxim Zyskin (maxim.zyskin@utb.edu)
University of Texas at Brownsville
Title: "Reinforcing polymer fibers"
Abstract: We obtain an explicit solution of equations of linear elasticity describing polymer fiber with reinforced outer layer. We analyze our solution to find response of reinforced system to non-uniform loads having narrow spatial peaks, and to estimate yield stress. We discuss nonlinear elasticty modeling of such systems.