

Logistics

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 - Taping anything to the glass doors or painted walls
 - Moving furniture from room to room
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Program with Abstracts

FRIDAY, MARCH 19

07:00pm Informal Reception, Mitch's Tavern

SATURDAY, MARCH 20

07:30am Registration Opens (SAS Hall Lobby)

08:40am - 09:00am Opening Remarks, *Dean Solomon*, SAS 2203

09:00am - 10:00am Plenary Talk 1, *Michael W. Berry*, SAS 2203

Discovering Gene Functional Relationships Using Nonnegative Matrix Factorization Models of Biomedical Literature.

Michael W. Berry (berry@eecs.utk.edu)

The University of Tennessee

Moderator: J. Scroggs

Joint work with

Ramin Homayouni, University of Memphis, and

Elina Tjioe, University of California at San Francisco

Searching biomedical literature to extract novel functional relationships among genes remains a challenge in the field of bioinformatics. While numerous software tools have been developed to extract and identify gene relationships from biological databases, few effectively deal with extracting new (or implied) gene relationships, a process which is useful in interpretation of discovery-oriented genome-wide experiments. In this study, we develop a Web-based bioinformatics software environment called FAUN or Feature Annotation Using Nonnegative matrix factorization (NMF) to facilitate both the discovery and classification of functional relationships among genes. Both the computational complexity and parameterization of NMF for processing gene sets are discussed. FAUN is tested on a variety of gene document collections, and its utility and performance as a knowledge discovery tool is demonstrated using a set of genes associated with Autism.

10:00am - 10:30am Coffee Break

10:30am - 12:30pm Parallel Sessions

M1: Analysis on Numerical Solutions of Partial Differential Equations, Part 1. *Beyza Aslan* and *Kening Wang*, SAS 1102

A Parallel Solver for Three Dimensional Full-Stokes Ice Sheet Modeling

Presenter: *Lili Ju* (ju@math.sc.edu), University of South Carolina

The governing equations for modeling ice sheet evolution include a nonlinear Stokes system for momentum, an energy equation for temperature evolution, and a mass-conservation equation for ice thickness evolution. Desired solvers for the coupled system should be able to handle large-scale realistic data from land and space-based observatories and laboratory experiments and, more important, to take full advantages of the up-to-date high-performance computing power. Our current work focuses on the development of an efficient parallel finite element package for 3D full-Stokes ice sheet modeling. Our implementation utilizes the high-quality nonuniform centroidal Voronoi Delaunay triangulation (CVDT) meshing technology and existing popular parallel linear system solvers. Some numerical tests will also be presented.

Adaptive Finite Element Methods for Elliptic PDEs over Hierarchical T-meshes

Presenter: *Li Tian* (tian@math.psu.edu), Pennsylvania State University
Co-authors: *Qiang Du* (qdu@math.psu.edu), Pennsylvania State University

Isogeometric analysis based on NURBS (Non-Uniform Rational B-Splines) as basis functions preserves the exact geometry but suffers from the inconvenience of a purely local refinement. In this paper, we use the so called polynomial splines over hierarchical T-meshes (PHT-splines) to construct basis functions which share the similar properties as B-splines, and allow us to overcome the difficulty of refining a mesh locally. We present a residual-based a posteriori error estimate for the finite element discretization of elliptic equations using PHT-splines basis functions. Then numerical experiments are presented to verify the theoretical results and demonstrate the robustness of the error estimate.

Finite Element Approximation of a Two-strain SIS Model with Diffusion

Presenter: *Necibe Tuncer* (tuncer@ufl.edu), University of Florida

In this work, we consider a two-strain SIS model with diffusion and coefficients depending on space. One way to understand the role of spatial effects in epidemiology is to consider models with diffusion. Spatial dependence of the coefficients is necessary to account for transmissibility, recovery and other epidemiological characteristics that vary with location. We introduce the basic reproduction number, and invasion numbers for the SIS model and study the properties of the disease-free equilibrium and

endemic equilibria. We show that although in the corresponding space-independent SIS model the two strains will exclude each other, niche-partitioning mechanisms in the diffusion model may allow for coexistence of the strains.

Our two strain model is based on the single strain SIS model considered in L. J. S. Allen, B. M. Bolker, Y. You, A.L. Nevai, Asymptotic profiles of the steady states for an SIS epidemic reaction-diffusion model, *Discrete and Continuous Dynamical Systems*, 21, (2008) 1-20.

A High Order Weakly Over-penalized Interior Penalty Method

Presenter: *Luke Owens* (owensl@math.tamu.edu), Texas A&M University
 Co-authors: *Susanne C. Brenner* (brenner@math.lsu.edu), Louisiana State University;
 and *Li-yeng Sung* (sung@math.lsu.edu), Louisiana State University

In this talk we will analyze a high order weakly over-penalized interior penalty method. It is the jumps across element edges that are weakly over-penalized, which allows us to recover a quasi-optimal bound in the L_2 norm. Error estimates in the energy norm are also established. In addition, we construct a simple block diagonal pre-conditioner that reduces the condition number of the discrete system from $O(h^{2r+2})$ to $O(h^2)$, where r is the polynomial degree and h is the mesh size.

M3: Dynamics and Control, Part 1. *Dmitry Zenkov* and *Scott Kelly*, SAS 2102

The rolling sphere and quantum spin

Presenter: *Anthony Bloch* (abloch@umich.edu), University of Michigan
 Co-author: *Alberto Rojo* (rojo@oakland.edu), Oakland University

In this talk we discuss the kinematics of a rolling sphere on a plane and on a curved surface, In particular we discuss how much the sphere rotates when it rolls and we relate this rotation to the precession of a spin half particle in a magnetic field. In this work we extend to the rolling setting the equivalence between the motion of rigid body and a two level quantum system. We discuss the general case and the adiabatic limit.

Generalization of the Method of Interconnection and Damping Assignment Passivity-Based Control

Presenter: *Dong Eui Chang* (dechang@math.uwaterloo.ca), University of Waterloo

I present my recent results on the generalization of the method of Interconnection and Damping Assignment Passivity-Based Control (IDA-PBC) for the stabilization of mechanical systems. First, we replace the skew symmetry property of the interconnection matrix with the energy conservation property. Second, we derive a new set of matching conditions simpler than those in the literature. Third, we provide a necessary

and sufficient condition for Lyapunov/exponential stabilizability by IDA-PBC for the class of all linear mechanical systems. Last, we give a necessary and sufficient condition for Lyapunov/exponential stabilizability by IDA-PBC for the class of all mechanical systems with one degree of underactuation. Our results comprehend and extend most results on IDA-PBC in the literature.

Matching and Stabilization of Discrete Mechanic Systems

Presenter: *Yuanyuan Peng* (ypeng2@ncsu.edu), North Carolina State University

In this talk we discuss the energy shaping approach to feedback stabilization of discrete mechanical systems with symmetry. To stabilize a (relative) equilibrium of interest, the kinetic energy is modified in order to obtain the dynamics of the controlled closed-loop system. The discrete controlled dynamics is used to construct a real-time model predictive controller with piecewise constant control inputs.

Quasivelocities in Nonholonomic Systems and Control

Presenter: *Dmitry Zenkov* (dvzenkov@ncsu.edu), North Carolina State University
 Co-authors: *Anthony Bloch* (abloch@umich.edu), University of Michigan; and *Jerrold Marsden* (jmarsden@caltech.edu), Caltech

Quasivelocities are the components of a mechanical system's velocity relative to a set of vector fields that are not associated with configuration coordinates. We will review the contemporary geometric exposition of quasivelocities and to discuss the use of quasivelocities in the design of stabilizing controllers.

M5: Mathematical Modeling of Biological Systems, Part 1. *Anita Layton*, SAS 2235

Myogenic Response of the Renal Afferent Arteriole

Presenter: *Anita Layton* (alayton@math.duke.edu), Duke University

We developed a mathematical model of an afferent arteriole, to be used as an essential component in models of integrated renal hemodynamic regulation. The model incorporates the ionic transports, cell-membrane potential, smooth muscle cell contraction, and the mechanics of a thick-walled cylinder. Also, myogenic response is incorporated, based on the hypothesis that the dependence of calcium-channel openings on voltage is shifted by changes in muscle stress, such that vessel diameter decreases with increasing pressure and vice versa.

Modeling and Numerical Simulations of the Fluid Dynamics of Feeding in the Upside Down Jellyfish, *Cassiopea* sp., Using Immersed Boundary Methods

Presenter: *Christina Hamlet* (chamlet@email.unc.edu), University of North Carolina

This presentation focuses on describing the scaling effects in feeding of the upside down jellyfish (*Cassiopeia* sp.) using computational fluid dynamics and live experiments. The immersed boundary simulate the bell of a jellyfish as an immersed, flexible boundary. A porous boundary represents the oral arms which protrude over the bell, altering the flow. The effect of the oral arms on vortex formation and on volumetric flow rates are analyzed across a range of Reynolds numbers.

A Mio-mechanical Model of Tumor Invasion: the Role of Intracellular Heterogeneity

Presenter: *Katarzyna Rejniak* (kasia@rejniak.net), Moffitt Cancer Research Institute

Cancer is a complex, multi-scale process in which genetic mutations occurring on a subcellular level manifest themselves as functional and morphological changes at the cellular and tissue scale. I will discuss the process of cancer invasion as defined by the emergence of a fingering morphology. Using the bio-mechanical model based on the immersed boundary method the direct interactions between individual cells and between cells and their microenvironment can be investigated. Heterogeneity and dynamics of cell membrane receptors and their driving role in the formation of cell invasive cohorts, as well as the impact of extrinsic (nutrient availability) and intrinsic (cell metabolism) factors on cell invasion will be explored.

Modeling Slender Biological Objects With Regularized Stokeslets

Presenter: *Elizabeth Bouzarth* (bouzarth@math.duke.edu), Duke University

The method of regularized Stokeslets provides a way to calculate fluid velocities in the Stokes flow regime due to regularized point-forces. In this discussion, the method of regularized Stokeslets is used to model rigid and flexible immersed slender objects inspired by several biological applications. Modeling these objects can introduce stiffness into the underlying system of ODEs, which motivates the development of additional explicit numerical integration techniques to handle such situations.

M6: Mathematical Modeling in Life Sciences: Control and Optimization, Part 1. Abdessamad Tridane and Virginia Pasour, SAS 2229**Impulse Control of Biological Systems**

Presenter: *Rachel Leander* (leander@math.utk.edu), University of Tennessee

Co-author: *Suzanne Lenhart*, University of Tennessee

Many biological processes are modeled as continuous dynamical systems in which states evolve according to differential equations. Tumor growth and ecological invasions are examples of such processes. Meanwhile, human interventions into these processes are typically discrete. For example, the administration of drugs, the application of pesticides, and the release of predators are all essentially discrete tasks. As a result many biological control problems give rise to simple impulse control problems.

Impulse control problems are generally solved via related partial differential equations known as variational inequalities. However, we will consider a simple type of impulse control problem that can be recast as a discrete optimal control problem. This formulation is advantageous because it is often simpler to solve the finite dimensional problems of discrete optimal control than the infinite dimensional variational inequalities.

Multiple Periodic Antiviral Drug Treatments in a Within-Host Virus Model.

Presenter: *Cameron J. Browne* (cambro@ufl.edu), University of Florida

Co-author: *Patrick DeLeenheer*, University of Florida

Perturbation techniques are used to investigate the effect that periodic antiviral treatments have on the standard within-host virus model. The model looked at is commonly used to model the HIV virus. When a combination therapy of RT and P inhibitors is used, it is found that the timing between the dosages of the RT and P inhibitors can be important in determining the treatment outcome.

Optimal Control of a Cholera Model

Presenter: *Peng Zhong* (zhong@math.utk.edu), University of Tennessee

Co-author: *Suzanne Lenhart*, University of Tennessee

This work is to find an optimal vaccination rate that minimizes the economic and social losses in an ODE model of cholera. This model contains nine equations tracking movement of susceptible individuals with and without partial immunities. A vaccinated class and age structure are added into this model and the vaccination rate is a control function. Both analytical and numerical results are discussed.

Dynamics of Distributions of Bacterial Emboli in Flow

Presenter: *David M. Bortz* (dmbortz@colorado.edu), University of Colorado at Boulder

We consider a model for the dynamics of bacterial aggregates in a hydrodynamic system, such as for example bacteria in the blood stream. We model a size-structured population based on the Smoluchowski coagulation equations, a nonlinear transport PDE. We discuss evidence that a widely used post-fragmentation distribution is incorrect as well as properties of growth leading to self-similar solutions to the equations.

M7: Modeling in Biomechanics and Bioengineering, Part 1. *Mansoor Haider* and *Sarah Olson*, SAS 2225

Biomechanics of the Cellular Microenvironment in Articular Cartilage

Presenter: *Mansoor A Haider* (m_haider@ncsu.edu), North Carolina State University

Cartilage cells (chondrocytes) are sparsely distributed within the tissues extracellular matrix (ECM), and their regulation of metabolic activity is highly dependent on the biomechanical environment of individual cells. Biphasic models idealize cartilage as a fluid-solid mixture, accounting for mechanisms including stress, strain, fluid pressurization, and fluid-solid drag, and reduce to elastic models under static mechanical loading. Each cell is encapsulated by a stiff pericellular matrix (PCM), which is hypothesized to serve dual roles as a protective layer, and as an amplifier of strains transduced to the cell. Computational modeling of this problem is challenging due to coupled effects among these distinct cartilage constituents (cell, PCM and ECM) spanning disparate length scales (micron to mm), and a wide range of elastic stiffness (kPa to MPa). In this talk, I will discuss computational models tailored to simulating inhomogeneous elastic and biphasic deformation in the biomechanical microenvironment of the cells in articular cartilage.

Mechanics of Fins, Krill, and Pollen Grains

Presenter: *Silas Alben* (alben@math.gatech.edu), Georgia Institute of Technology

We describe recent studies of three different systems in biomechanics. First, we consider how pollen grains of angiosperm flowers survive the process of dehydrating and rehydrating by simple geometrical and mechanical properties of the pollen wall. Second, we optimize a fin ray—the supporting structure in flexible fish fins—for stiffness. Third, we use a drag coefficient model of swimming krill to show that metachronal or syncopated propulsor dynamics are optimal for maximizing thrust and efficiency.

A Fast Quadrature-based Numerical Method for the Continuous Spectrum Biphasic Poroviscoelastic Model of Articular Cartilage

Presenter: *Michael Stuebner* (msteubn@ncsu.edu), North Carolina State University

Cartilage deformation is described by the linear poroviscoelastic model, accounting for both flow-dependent and flow-independent dissipation mechanisms. Intrinsic dissipation is modeled using a constitutive relation where the solid stress depends on strain rate via a time integral with a continuous relaxation spectrum. We present an efficient method that avoids the prohibitive cost of the hereditary integral via a quadrature approximation of the relaxation function that results in a separable formulation.

Mechanics and Engineering Challenges Associated with Lung Mucus

Presenter: *Greg Forest* (forest@amath.unc.edu), University of North Carolina, Chapel Hill

This talk will address a host of open problems associated with lung mucus, and some progress. The challenges involve flow transport of mucus layers, diffusive transport of particles in mucus layers, and the role of mechanical stresses in maintaining a sufficiently hydrated mucus layer. These projects are part of the Virtual Lung Project at UNC which involves collaborators across the basic sciences and the Cystic Fibrosis Center.

M10: Stochastic Models and Applications, Part 1. *T.E. Govindan*, SAS 1108

Derivation of Stochastic Differential Equations for Sunspot Activity and For Reaction-Diffusion Problems

Presenter: *Edward Allen* (edward.allen@ttu.edu), Texas Tech University
Co-authors: *Elife Dogan* (elifedogan@ttu.edu), and *Chisum Huff* (chisum.huff@ttu.edu), Texas Tech University

A system of stochastic differential equations (SDEs) is derived for sunspot activity. It is assumed that there exists a randomly varying periodic source of sunspots and that the probability of sunspot decay is proportional to time. The derived model is tested against sunspot data for three 11-year cycles. The results are interesting in that certain characteristics are shared by both the SDE model and the data. In particular, the second and third moments about the mean divided by the mean are similar for the SDE model and the data and appear to be approximately constant over the sunspot cycle. In addition, stochastic partial differential equations (SPDEs) are derived for reaction-diffusion problems. Comparisons between computational solutions of the SPDEs and Monte Carlo calculations support the accuracy of the derivations.

McKean-Vlasov Stochastic Equations: Past, Present, and Future Directions

Presenter: *Mark McKibben* (mmckibben@goucher.edu), Goucher College, Baltimore, Maryland

The study of McKean-Vlasov equations arose initially with the work of H.P. McKean in 1966 when investigating the dynamics of systems of interacting particles, as in statistical mechanics and chromatography. Such equations are characterized by nonlinear stochastic evolution equations whose forcing terms depend on both the state of the process and its probability law. The research on this topic has received significant attention in the subsequent 40+ years, and one of the most recent advancements is the study of their relationship in describing infinite-dimensional nonlinear diffusions. This talk will recount some of the history of this area of research, as well as discuss current and future efforts, including the study of such equations driven by fractional Brownian motion and those equipped with impulses and infinite delay.

Asymptotic Properties and Immortal Particle in a Catalytic Branching Process

Presenter: *Min Kang* (mkang2@unity.ncsu.edu), NCSU

We study the existence and some asymptotic properties of a conservative branching particle system for which birth and death are triggered by contact with a set (catalyst). Sufficient conditions for the process to be non-explosive are given, solving a long standing open problem. With probability one, it is shown that only one ancestry survives. In special cases, the evolution of the surviving particle is studied and for a two particle system on a half line we derive explicitly the transition function of a chain representing the position at successive branching times.

Stochastic Portfolio Optimization with Bounded Memory

Presenter: *Tao Pang* (tpang@ncsu.edu), NCSU

This paper considers a portfolio management problem of Merton's type in which the risky asset return is related to the return history. The problem is modeled by a stochastic system with delay. The investor's goal is to choose the investment control as well as the consumption control to maximize his total expected, discounted utility. The HJB equation is derived by virtue of dynamic programming principle. Under certain situations, we derive the explicit solutions in a finite dimensional space.

M11: Teaching Undergraduate Mathematics, Part 1. *Alina Duca*, SAS 1216

Relational Understanding of Procedures in Differential Equations

Presenter: *Karen Keene* (karen.keene@ncsu.edu), NCSU Mathematics Education

This presentation will report on the results of research that investigated "cognitive tutoring for conceptual understanding" in a first course in differential equations. Using definitions and frameworks for procedural knowledge in the literature, such as that presented by Star (2005), Hasselbrank and Hodson (2007) and the National Council of Teachers of Mathematics, the presenter will offer an educational framework for "relational understanding of procedures". This framework informs instructors when they are teaching differential equations if they choose to emphasize more conceptual knowledge, and not just the "how to".

Let Students Use Their *Own* Mind

Presenter: *Dan Teague* (teague@ncssm.edu), NC School of Science and Mathematics

Developing mathematical talent requires posing appropriately challenging problems for which students have no ready-made solution. By capitalizing on the students' capacity to be puzzled, and the natural desire to find a way out of that puzzle, we enable students to experience small mathematical investigations repeatedly throughout their coursework. Example problems and mathematical models from Discrete Mathematics, Calculus, and Differential Equations will be presented.

Using Guided Classroom Worksheets to Promote Continuous Assessment

Presenter: *Jack Bookman* (bookman@math.duke.edu), Duke University

This presentation will address how to construct and use guided class notes in first year Calculus classes and how they can be used to continuously assess and monitor student progress that goes beyond formal, occasional assessment opportunities (e.g., tests). Strengths and weaknesses of various teaching strategies will be discussed with specific emphasis on enabling the teacher to observe and assess what students are learning. Examples of guided class notes will be shown.

Computer Labs for Non-Euclidean Geometry

Presenter: *Irina Kogan* (iakogan@ncsu.edu), North Carolina State University

Foundations of Euclidean Geometry course at NCSU (MA 408) is a required course for Mathematics Education students, who intend to teach mathematics at the high-school level. It is also taken as an elective by students majoring in mathematics, physics and engineering. The course is devoted to building geometric theory in a rigorous way starting from axioms. To give students a deeper appreciation of

the axiomatic approach, the course compares Euclidean geometry with hyperbolic geometry. It is, however, challenging for many students to visualize and accept counterintuitive phenomena of hyperbolic geometry. In collaboration with Karen Hollebrands from the Department of Math Education at NCSU and with participation of several graduate students, we developed computer laboratories that help students explore the unfamiliar world of hyperbolic geometry. I will describe these laboratories and share some observations about their impact on students learning.

M12: Undergraduate Computational Education. *R.E. White*, SAS 1120

Computational Science Course Work for First and Second Year Undergraduates

Presenter: *Robert White* (white@math.ncsu.edu), North Carolina State University

Five undergraduate courses, which have significant computational science components, will be described: introduction to programming (MA 116), elements of matrices (MA 205), introduction to applied mathematics (MA 325), and two one-credit courses on computation for the life and management science (MA 132) and numerical solution of ODEs (MA 302). These courses require at least one semester of calculus and have some applications, numerical modeling and computations. These courses give the student rudimentary computational skills and prepare the student for additional course work in their third and fourth year of study.

Image Compression Introduction to Wavelets

Presenter: *Colm Mulcahy* (colm@spelman.edu), Spelman College

Since the mid 1990s, I've utilized an elementary approach to image compression using Haar wavelets, together with basic Matlab coding, to introduce independent study students to modern applications of mathematics in fields such as image processing and computer graphics. It also serves to reinforce key concepts in linear algebra.

Computational Education in Mathematics Motivates Students and Enhances Students Learning

Presenter: *Mohammad Siddique* (msiddiqu@uncfsu.edu), Fayetteville State University, NC

In this talk, we will discuss a common myth about mathematics that mathematics is a complicated and difficult subject to grasp. This myth can be given the name as math anxiety which is quite common within the students community and has been the subject of discussion worldwide, as well as many conferences and seminars related to education. With this in mind we have, like many others teaching mathematics, always thought of ways and means of making mathematics simple, interesting, and attractive. As most of our students have grown up in a technologically rich environment, so they are in fact more comfortable in learning from electronic sources, than from traditional, printed or hard copy alternatives. Use of Computer technology in math

offers students a better means to visualize and grasp difficult concepts. We use this effective methodology for the instruction of mathematics to achieve the goals.

Title TBA

Presenter: *Robert Panoff*

Late Abstract

C1: Contributed Session 1, SAS 2106

A Stability Study of a new Explicit Numerical Scheme for a System of Differential Equations with a Large Skew-Symmetric Component

Presenter: *Katharine Gurski* (kgurski@howard.edu), Howard University

Co-author: *Stephen O'Sullivan* (steve.osullivan@dcu.ie), Dublin City University

Explicit numerical methods for the solution of a system of differential equations dominated by a skew-symmetric component suffer from a time step size that approaches zero in order to satisfy stability conditions. We present and compare analytical results for several explicit methods including the super-time-stepping method of Alexiades, Amiez, and Gremaud and our new method modeled on a predictor-corrector scheme with multiplicative operator splitting presented in regular and super-time-stepping forms.

Stability by Fixed Point Theory for Neutral Delay Differential Equations

Presenter: *Bo Zhang* (bzhang@uncfsu.edu), Fayetteville State University

This is a paper in a series investigations into the use of fixed theorems to prove stability. Here we use a fixed point theorem of Krasnoselskii-Schaefer type. The work concerns the stability properties of a general system of neutral delay differential equations. Such problems have proven very challenging in the theory of Liapunov's direct method. We show that it fits very nicely into the framework of the fixed theorem mentioned above so that asymptotic stability is readily concluded.

A New Class of Symmetry Reductions for Parameter Identification Problem

Presenter: *Nicoleta V. Bila* (nbila@uncfsu.edu), Fayetteville State University

Co-author: *Jitse Niesen* (jitse@maths.leeds.ac.uk), University of Leeds

A new type of symmetry reductions called extended nonclassical symmetries related to parameter identification problems described by partial differential equations is introduced. Including the data function in the parameter space allows one to find specific data and parameter classes that lead to a reduced dimension model. Since the extended nonclassical symmetries relate the forward and inverse problems, the

dimension of the studied equation may be reduced by expressing the data and parameter in terms of the group invariants. The main advantage of these new symmetries is that they may be incorporated into the boundary conditions as well, and, consequently, the dimension reduction problem can be analyzed on new types of domains. Special group-invariant solutions or additional information on the parameter can be obtained. Our MAPLE routine GENDEFNC which uses the package DESOLV (authors Carminati and Vu) has been updated for this propose and its output is the nonlinear partial differential equation system of the determining equations of the extended nonclassical symmetries.

On Construction of Energy Stable WENO Schemes of Any Order

Presenter: *Nail K. Yamaleev* (nkyamale@ncat.edu), North Carolina A&T State University

Co-author: *Mark H. Carpenter* (m.h.carpenter@nasa.gov), NASA Langley Research Center

We present a systematic methodology for constructing *Energy Stable WENO* finite difference schemes of arbitrary order. The new ESWENO schemes are proven to be stable in the L_2 -energy norm for both continuous and discontinuous solutions of hyperbolic systems. We show that the symmetric part of conventional WENO operators has positive eigenvalues; thus, the WENO schemes may become locally unstable. We also present new weight functions and constraints on their parameters, which provide consistency, much faster convergence of the high-order ESWENO schemes to their underlying linear schemes for smooth solutions with arbitrary number of vanishing derivatives, and better resolution near strong discontinuities than the conventional counterparts.

C2: Contributed Session 2, SAS 1218

Two-Level Discretizations of Closure Models for Proper Orthogonal Decomposition

Presenter: *Zhu Wang* (wangzhu@vt.edu), Virginia Tech

Co-authors: *Imran Akhtar* (akhtar@vt.edu), Virginia Tech; *Jeff Borggaard* (jborggaard@vt.edu), Virginia Tech; and *Traian Iliescu* (iliescu@vt.edu), Virginia Tech

One of the main hurdles in the development of modern closure models in Proper Orthogonal Decomposition of turbulent flows has been the lack of efficient computational strategies for the discretization of the associated nonlinearities. We introduce a two-level discretization methodology that reduces dramatically the computational cost without compromising the accuracy of the closure model. This is demonstrated numerically in the 3D simulation of a flow past a cylinder at $Re=1,000$.

Adaptive Interpolation Method

Presenter: *Kevin R. Pond* (kevin.pond@vt.edu), Virginia Tech

Stochastic differential equations are used to model real world systems. For example, modeling groundwater flow requires information about subsurface properties including porosity and permeability which are represented by random variables in the SDE. Currently, solving such problems demands new code, the execution of legacy code numerous times or global smoothness assumptions. We will present an adaptive interpolation method that requires a low number of function evaluations through legacy code and does not require function smoothness.

An Efficient Implementation of the Variational Monte Carlo Method

Presenter: *Kapil Ahuja* (kahuja@vt.edu), Virginia Tech

Co-authors: *Bryan Clark* (bclark@princeton.edu), Princeton University; *Eric de Sturler* (sturler@vt.edu), Virginia Tech.; *David Ceperley* (ceperley@illinois.edu), Univ. of Illinois at Urbana-Champaign.

Quantum Monte Carlo (QMC) methods have a ubiquitous role in computational physics. The main cost of any QMC method, for example the variational Monte Carlo (VMC) method, is in constructing Slater matrices and in computing determinant ratios. Most of the recent physics papers discuss (and improve) only the scaling of constructing Slater matrices. In this talk we improve the scaling of computing the determinant ratios in the VMC method by using a preconditioned iterative solver. Our most important contribution is in making the preconditioner work. Standard preconditioners don't work well because either the preconditioner does not exist or it is too expensive to compute and apply. To overcome these problems we perform two algorithmic improvements. The first involves cheap updates to the preconditioner exploiting the fact that the Slater matrix changes only by a row between two consecutive Monte Carlo steps. The second improvement involves a geometric reordering of particles and orbitals that increases the near-diagonal dominance of the Slater matrix. The cost of computing determinant ratios using our algorithm is slightly worse than $\mathcal{O}(n^2)$ per sweep as compared to $\mathcal{O}(n^3)$ per sweep using the traditional algorithms, where n is the system size and a sweep is an attempt to move each particle in the system once.

On the Randić index and extremal Cacti

Presenter: *Daniel Gray* (dg0064-gw@georgiasouthern.edu), Georgia Southern University

Co-author: *H. Wang* (hwang@georgiasouthern.edu), Georgia Southern University

The Randić index of a graph G is the sum of $((d(u))(d(v)))^\alpha$ over all edges uv of G , where $d(v)$ denotes the degree of v in G , $\alpha \neq 0$. Earlier in Discrete Applied Mathematics, Lin, Luo and Zha provided a sharp lower bound for the Randić index of cacti with given number of pendant edges, in the case of $\alpha = -\frac{1}{2}$. In this short note we seek to provide some results regarding the extremal cacti with respect to general Randić indices (i.e. $0 \neq \alpha \in [-1, 1]$) for cacti with given number of vertices, pendant

edges and cycles. We conjecture that the extremal cacti in this category must be in a special group, a formula for the Randić index of these special cacti is provided. More generally, our approach lead to a single inequality for any value of α , the verification of which will result in a simple proof of our conjecture for the specific value of α . As an application, characterizations of the extremal cacti for the weight (special case of the Randić index when $\alpha = 1$) with various restrictions can be immediately achieved.

12:30pm - 02:00pm Box Lunch

02:00pm - 03:00pm Plenary Talk 2, Nonlinear Waves: From Beaches to Lasers. *Mark J. Ablowitz*, SAS 2203

Nonlinear Waves: From Beaches to Lasers

Mark J. Ablowitz (mark.ablowitz@colorado.edu)

The University of Colorado at Boulder

Moderator: M Hofer

The study of localized waves has a long history dating back to the discoveries in the 1800s by Russell, Boussinesq and Korteweg-deVries (KdV) describing water waves in shallow water. In the 1960s research on the KdV equation led to the concept of solitons which are solitary waves which interact “elastically. More recently both in fluid dynamics and nonlinear optics there has been considerable interest in various aspects of localized waves. Some of the topics that will be briefly discussed include: cross-wave interactions in water waves, ultra-short pulse dynamics in lasers and nonlinear waves in optical lattices.

03:00pm - 03:30pm Snack Break

03:30pm - 05:30pm Parallel Sessions

M1: Analysis on Numerical Solutions of Partial Differential Equations, Part 2. *Beyza Aslan* and *Kening Wang*, SAS 1102

An Introduction to Spectrally Matched Optimal Grids

Presenter: *Adnan Sabuwala* (asabuwala@csufresno.edu) California State University, Fresno

In this talk, we will first introduce the Padé-Chebyshev grids. In particular, we will demonstrate how these sets of optimal grids are constructed. We will study Laplace’s equation with a semi-discretization using these optimal grids. We will also introduce the Remes grids and compare them to the Padé- Chebyshev grids in terms of the

error convergence rate for the solution. Finally, we will investigate the application of the spectrally matched grids to an anisotropic problem.

Quadratic Immersed Finite Elements for Interface Problems, using Discontinuous Galerkin method

Presenter: *Mohamed Ben Romdhane* (romdhane@vt.edu), Virginia Tech
Co-authors: Slimane Adjerid (adjerids@vt.edu), and *Tao Lin* (tlin@vt.edu), Virginia Tech

In our article, we present a flexible Finite Elements (FE) method that combines features of Immersed Finite Elements (IFE) with Discontinuous Galerkin (DG) methods for solving elliptic boundary value problems with discontinuous coefficients in 2D. A main feature of IFE is to allow using structured meshes and to give a flexibility for mesh refinement. The use of a DG formulation for the IFE method ensures the optimal rate of convergence in the L2 and H1 norms, under h-refinements. The main goal of our article here is to present a Quadratic IFE space in which numerical solutions are able to optimally represent the non-smooth behavior of the solution across the interfaces, without requiring the mesh to be aligned with the discontinuity. Different interface jump conditions are employed and justified. Numerical results (for interface problems with structured mesh and mesh refinement) are presented and discussed to illustrate features of these DG-IFE. A proof for the existence and uniqueness of the quadratic immersed shape functions is presented, as well.

M3: Dynamics and Control, Part 2. *Dmitry Zenkov* and *Scott Kelly*, SAS 2102

Gravity Powered Locomotion and Active Control of a Family of Planar Robotic Mechanisms

Presenter: *Yildirim Hurmuzlu* (hurmuzlu@lyle.smu.edu), Southern Methodist University
Co-author: *Ali Tavakoli* (atavakolit@lyle.smu.edu), Southern Methodist University

The goal of our research is to develop a family of energetically efficient versatile robots. Evolutionary biology teaches us that one can learn a great deal by studying the hereditary traits of organisms that evolve over generations. Thus, we foresee great benefits in analyzing a chain of mechanisms that span from the very simple to the progressively more complicated. Hence, our goal is to generate a family of planar mechanisms, with members that can be as simple as a bouncing ball or as complex as a five link biped. We study the gravity powered locomotion of the members of this family by placing them on inclined planes.

Transport Networks: Mapping Chaotic Motion in the Solar System and Geophysical Flows via Invariant Manifolds

Presenter: *Shane Ross* (sdross@vt.edu), Virginia Tech

The competing gravitational pull between celestial bodies creates a vast array of passageways that winds around the sun, planets and moons. These corridors are tube-like invariant manifold structures connecting regions of balance in interlinked three body problems. A collaboration of researchers has explored this complex interplanetary transport network, which not only influences the fate of comets, but may facilitate the exploration of the Moon, the asteroids, and the outer solar system, including a mission to assess the possibility of life on Jupiter's icy moons. The talk will summarize these ideas, including their relationship to other dynamical systems problems, particularly the atmospheric transport network and the role of invariant manifold-like transport barriers in the biological invasion of airborne microorganisms.

Oblique Shock Waves in Dispersive Eulerian Fluids

Presenter: *Mark Hoefler* (mahoefer@ncsu.edu), North Carolina State University
Co-author: *Boaz Ilan* (bilan@ucmerced.edu), University of California, Merced

Two-dimensional, non-stationary oblique shock waves in a class of dispersive Eulerian fluids will be constructed using Whitham averaging. This construction takes advantage of irrotationality and recently developed methods for Whitham averaging of one-dimensional, non-integrable equations. Example applications to Nonlinear Schrödinger (NLS) flows, water waves, ion-acoustic plasma, and optical media with saturable nonlinearity will be presented. Connections to supersonic dispersive, NLS flow over corners will also be discussed.

A Bent Spinning Rod in a Viscous Fluid: Symmetry Breaking and Tori

Presenter: *Richard McLaughlin* (rmm@amath.unc.edu), UNC Chapel Hill
Co-authors: *Roberto Camassa* (camassa@amath.unc.edu), *Leandra Vicci* (vicci@cs.unc.edu), and *Longhua Zhao* (zlh@email.unc.edu), UNC Chapel Hill.

We consider the fluid motion induced by a spinning bent rod in a viscous fluid using experimental and theoretical methods. The geometrical effect of a bent rod is shown to create nested tori in the Lagrangian fluid particle trajectories, and effect absent for straight rods. We explore the capability of slender body asymptotic methods using images to maintain no-slip on a plane floor in matching the experiment over short, intermediate, and long times. Fully three dimensional experimental particle tracking is compared directly to slender body theory, and issues regarding the long time (thousands of rotation) comparisons.

M4: Probability and Stochastic Analysis. *Min Kang*, SAS 1218**Renormalization in the Model of Brownian Motions in Poissonian Potentials**

Presenter: *Xia Chen* (xchen@math.utk.edu), University of Tennessee

The model of Brownian motion in Poissonian potential describes a typical trajectory of a Brownian particle surviving from being attracted by the obstacles randomly located in the space (think about the stars in the universe). In the existing literature, the random potential is defined as the convolution between a Poissonian field and a bounded and locally supported function.

According to the Newton's law of universal attraction and some other related laws in physics, the most natural way of constructing the random potential is to define it as the Riesz potential of the Poissonian field. On the other hand, the Riesz potential of the Poissonian field blows up.

In this talk, this problem will be fixed by the way of renormalization. In addition, some asymptotic patterns of our models will be established and more problems will be asked. Part of the talk is based on some collaborative works with Kulic and Rosen.

Nonuniqueness for Some Stochastic PDE

Presenter: *Carl Mueller* (SIAM-2010@carlm.e4ward.com), University of Rochester

The superprocess is one of the most widely studied models in probability. It arises as a limit of population processes which depend on space as well as time. One long-standing question involves the uniqueness of the stochastic PDE which describes the superprocess. Due to randomness, standard results about uniqueness of PDE do not apply. We will describe joint work with Barlow, Mytnik, and Perkins, in which we prove nonuniqueness for the equation describing the superprocess. Our results generalize to several related equations.

Variational Representations and Large Deviations

Presenter: *Amarjit Budhiraja* (budhiraj@email.unc.edu), University of North Carolina at Chapel Hill

Certain variational representations for infinite dimensional Brownian motions and Poisson random measures will be described. Applications of these to the study of small noise large deviations will be presented. The talk is based on joint works with P. Dupuis and V. Maroulas.

Deriving the Distribution of Genetic Statistics for a Class of Coalescent Processes

Presenter: *Sivan Leviyang* (sr286@georgetown.edu), Georgetown University

In the field of population genetics, a variety of statistics formed from genetic samples are used to study the evolutionary forces acting on a given population. The distributions of most such genetic statistics are not known. Coalescent processes are Markov processes used to model the genetic composition of a population. Importantly, the distribution of a genetic statistic depends on the underlying coalescent process that is assumed. This makes inference difficult. In this talk we will introduce a class of coalescent process which we refer to as G/KC coalescents. For this entire class, we will derive the so-called large sample limit of various genetic statistics. We will discuss the relevance of our results to application and mention some open problems.

M5: Mathematical Modeling of Biological Systems, Part 2. *Anita Layton*, SAS 2235

Speed Versus Robustness in Feed-forward Biochemical Reaction Networks

Presenter: *John W. Cain* (jwcain@vcu.edu), Virginia Commonwealth University

Many of the functional substructures of metabolic and signaling pathway networks are "feed-forward" in the sense that they can be rendered schematically as cycle-free directed graphs. Glycolysis (conversion of sugars into energy) and apoptosis (programmed cell death) provide prime examples of such networks. Using differential equations to model the dynamics of feed-forward networks, we find that topologically non-isomorphic networks of the same "size" can yield approximately identical dynamical behavior. Among networks with similar dynamics, does evolution prefer certain structures over others and, if so, why? The preliminary data that we shall present indicate that nature places a premium on robustness as opposed to speed/efficiency.

Dynamics of hepatitis B virus infection: what causes viral clearance?

Presenter: *Anne Catlla* (CatllaAJ@Wofford.Edu), Wofford College

Hepatitis B infects liver cells, leading to acute infection or chronic liver disease. The mechanisms responsible for the infection outcome are uncertain, with immune responses involved in curing and killing of infected cells. We consider two models of hepatitis B infection, using stability analyses and simulations to examine the roles of each immune response. We find that total strength of immune response determines infection outcome and relative strengths of each type of response affect transient dynamics.

Root Hair Formation in Arabidopsis Thaliana

Presenter: *David Gammack* (David.Gammack@marymount.edu), Marymount University

Arabidopsis thaliana is a plant from the mustard family and is used as a model organism for developmental biologists. The cross section of a wild-type root can be thought of as two concentric circles: an outer circle of roughly 20 epidermal cells encapsulating an inner circle of roughly 8 cortical cells. The epidermal cells can differentiate into hair cells, which expand laterally to form long tubular outgrowths, or into non-hair cells. Cellular differentiation depends on various transcription factors and chemical complexes. We present a mathematical model of the *A. thaliana* root that allows us to study the effects of positional cues that are thought to give rise to the spatial patterning seen *in vivo*.

A Mathematical Model of Oxygen Transport in Rat Outer Medulla

Presenter: *Jing Chen* (jchen@math.duke.edu), Duke University

We developed a mathematical model to study the oxygen distribution in the rat outer medulla. The model predicts that the structural organization of outer medulla results in significant oxygen tension gradients both in the axial and the radial directions. (The segregation of descending vasa recta helps preserve oxygen delivery to the inner medulla.) The model also suggests that the oxygen availability to medullary thick ascending limbs has a significant impact on active NaCl reabsorption and the concentrating capability of the outer medulla.

M6: Mathematical Modeling in Life Sciences: Control and Optimization, Part 2. *Abdessamad Tridane* and *Virginia Pasour*, SAS 2229

A Comparison of Nonlinear Filtering Approaches in the Context of an HIV Model

Presenter: *H.T. Banks* (htbanks@ncsu.edu), North Carolina State University

Co-authors: *S. Hu*, *Z. Kenz*, and *H.T. Tran*, North Carolina State University

In this lecture three different filtering methods, the Extended Kalman Filter (EKF), the Gauss-Hermite Filter (GHF), and the Unscented Kalman Filter (UKF), are compared for state-only and coupled state and parameter estimation when used with log state variables of a model of the immunologic response to the human immunodeficiency virus (HIV) in individuals. The filters are implemented to estimate model states as well as model parameters from simulated noisy data, and are compared in terms of estimation accuracy and computational time. Numerical experiments reveal that the GHF is the most computationally expensive algorithm, while the EKF is the least expensive one. In addition, computational experiments suggest that there is little difference in the estimation accuracy between the UKF and GHF. When measurements are taken as frequently as every week to two weeks, the EKF is the superior filter. When measurements are further apart, the UKF is the best choice

in the problem under investigation. The results are especially important in HIV estimation and feedback control efforts where observations are typically two weeks to one month apart. This represents joint efforts with

Mathematical Framework for Agent Based Models and Optimal Control

Presenter: *Franziska Hinkelmann* (fhinkel@vt.edu), Virginia Polytechnic Institute and State University

Co-authors: *David Murrugarra* (davidmur@vt.edu), *Abdul Salam Jarrah* (ajarrah@vbi.vt.edu), and *Reinhard Laubenbacher* (reinhard@vbi.vt.edu), Virginia Polytechnic Institute and State University

As a result of an investigative workshop at the National Institute for Mathematical and Biological Synthesis, we concluded that a unified mathematical language for agent based models is necessary to efficiently re-use and modify models. This is in accordance with Grimm et al., who established that agent or individual based simulations are “more difficult to analyze, understand, and communicate” than traditional analytical models because they are not “formulated in the general language of mathematics”, and proposed the standard protocol *ODD* (Overview, Design concepts, Details) as a first step to overcome the ambiguity of verbal model descriptions. We propose a mathematical framework that allows to represent a model described by ODD by mathematical equations and therefore provides a compact and exact representation of any model. Since the basic nature of most agent-based models is that of a time-discrete dynamical system on a finite state space (either deterministic or stochastic), any exact mathematical description has to represent them in this way. We describe such a class of dynamical systems, namely algebraic models. We show how an agent-based model described by the ODD protocol, can be represented by an algebraic model. One of the advantages of algebraic models in addition to rigorous mathematical language is that mathematical methods for optimal control have been developed. We will discuss optimal control strategies in this context.

An Optimal Control Problem for in vitro Virus Competition.

Presenter: *David Murrugarra* (davidmur@vbi.vt.edu), Virginia Polytechnic Institute and State University Affiliation Unknown

Co-authors: *Franziska Hinkelmann*, *Abdul Salam Jarraha*, and *Reinhard Laubenbacher*, Virginia Polytechnic Institute and State University

Polynomial dynamical systems (PDS) over finite fields is a framework to model agent based models (ABM) and individual based models (IBM). PDS can be studied from the point of view of control theory, which provides access to the rich algorithmic theory of computer algebra and the theoretical foundation of algebraic geometry. Jarrah et al. [3] made the first attempt to formulate an optimal control problem using this framework for a model of in vitro virus competition. The idea for control they present is the use of a relatively benign pathogen with a competitive advantage to contain a more harmful one, which is an important and relatively new concept in infectious disease management. In this talk, I present a slightly different way to

control the system and I solve the optimal control problem using Bellmans backtracking algorithm

Optimal Control of Cardiac Alternans

Presenter: *Xiaopeng Zhao* (xzhao9@utk.edu), University of Tennessee

Co-authors: *Henian Xia coAuthor* , and *Suzanne Lenhart* , University of Tennessee

Cardiac alternans is a marker of sudden cardiac arrest, the leading cause of death in the United States, killing hundreds of thousands of Americans each year. In the language of nonlinear dynamics, cardiac alternans is an instability mediated by a period-doubling bifurcation. Feedback control techniques have been exploited to suppress this bifurcation. However, due to spatial effect, control techniques can eliminate alternans only in a limited area of the cardiac tissue. In this work, we explore optimal control techniques to guide the choice of control input to achieve the best antiarrhythmic effect. Numerical examples are presented to demonstrate the control methodology.

M7: Modeling in Biomechanics and Bioengineering, Part 2. *Mansoor Haider* and *Sarah Olson*, SAS 2225

An integrative model of sperm motility

Presenter: *Sarah Olson* (solson2@tulane.edu), Tulane University

Co-authors: *Susan Suarez*, Cornell University; and *Lisa Fauci*, Tulane University

Calcium (Ca^{2+}) dynamics in mammalian sperm are directly linked to motility. These dynamics depend on diffusion, nonlinear fluxes, Ca^{2+} channels specific to the sperm flagellum, and other signaling molecules. The goal of this work is to couple Ca^{2+} dynamics to a mechanical model of a motile sperm within a viscous, incompressible fluid. We will present recent progress on elements of this integrative model.

Flying and Parachuting in the Smallest Flying Insects

Presenter: *Laura A. Miller* (lam9@email.unc.edu), University of North Carolina, Chapel Hill

A vast body of research has described the complexity of flight in insects ranging from the fruit fly, *Drosophila melanogaster*, to the hawk moth, *Manduca sexta*. Over this range of scales, flight aerodynamics as well as the relative lift and drag forces generated are surprisingly similar. The smallest flying insects have received far less attention, although previous work has shown that flight kinematics and aerodynamics can be significantly different. In this presentation, we have used a three-pronged approach that consists of measurements of flight kinematics in the tiny insect Thysanoptera (thrips), measurements of flow velocities using physical models, and direct numerical simulations to compute lift and drag forces. From high speed

videos, we find that thrips use clap and fling during flight and occasionally stop flapping and apparently parachute. Using physical models and CFD, we find that drag forces generating during clap and fling can be an order of magnitude larger than lift forces. The potential ecological consequences of flight performance will also be discussed.

The Mechanics of Tissue Dynamics

Presenter: *Sharon Lubkin* (lubkin@ncsu.edu), North Carolina State University

Tissues grow, change shape, and differentiate, function normally or abnormally, get diseased or injured, repair themselves, and sometimes atrophy. This complex suite of behaviors is governed by a complex suite of controls. Nonetheless, we can identify some general principles at work in the dynamics of tissues. Our goal is to understand how a tissues mechanics and biology regulate each other. Our models use a biologically-based continuum framework to track the mechanics, biology, and mechanobiology of the component cells, fluids, signaling molecules, and extracellular matrix materials. The presentation will describe our modeling approach, reveal some of the general principles we have identified, and discuss some of the questions our findings have raised about specific morphogenetic systems.

Biomechanics of Epithelial Tissue Formation and its Malignant Transformation

Presenter: *Katarzyna Rejniak* (Kasia.Rejniak@moffitt.org) H. Lee Moffitt Cancer Center & Research Institute

Epithelial tissues form highly selective barriers between different body compartments. They are composed from tightly packed cells that maintain an apical-basal polarity synchronized among all cells. In contrast, the disruption of such a well-organized epithelial architecture leads to various forms of epithelial tumors. In this talk, I will address several stages of the development of epithelial acini (an experimental 3D model of epithelial structures) using a bio-mechanical IBCell model and quantitatively compare computational results to experimental data. I will focus on the dynamics of cell membrane receptors that drive interactions between neighboring cells and between cells and their immediate microenvironment.

M10: Stochastic Models and Applications, Part 2. *T.E. Govindan*, SAS 1108

Long Wave Expansions for Water Waves over Random Bottom

Presenter: *Oliver Diaz* (odiaz@math.duke.edu), Duke University

We introduce a technique, based on perturbation theory for Hamiltonian PDEs, to derive the asymptotic equations of the motion of a free surface of a fluid over a

rough bottom (one dimension). The rough bottom is described by a realization of a stationary mixing process which varies on short length scales.

We show that the problem in this case does not fully homogenize, and random effects are as important as dispersive and nonlinear phenomena in the scaling regime. We will explain how these technique can be generalized to higher dimensions.

Statistical Analysis of Curve Fitting Methods in the Errors-In-Variables Model

Presenter: *Ali A Al-Sharadqah* (alsha1aa@uab.edu), University of Alabama at Birmingham

The task of fitting circles to observed points has tremendous applications in pattern recognition, computer vision and other sciences. Such a problem is notoriously difficult, because both coordinates of observed points are uncertain. Therefore this model is known as Errors-In-Variables (EIV) model.

Many algorithms have been developed that fit circles to data. Some minimize the geometric distances from the circle to the data points (we call them geometric fits). Others minimize various approximate (or ‘algebraic’) distances, they are called algebraic fits (Pratt fit, Hyper-accurate fit and Taubin fit).

After briefly discussing the most popular fits and adopting commonly standard assumptions on the statistical distribution of errors, we study the statistical properties of the estimates and prove that these fits return estimates with infinite moments. Finally we discuss methodological implications of this fact.

On Stochastic Neutral Partial Functional Differential Equations

Presenter: *T.E. Govindan* (tegovindan@yahoo.com), Instituto Politecnico Nacional, Mexico

In this talk, we address stochastic neutral partial functional differential equations in real Hilbert spaces. Our aim here is to introduce a new iteration procedure for such class of equations. Using this, we investigate the existence and uniqueness of a mild solution and also the almost sure exponential stability of its sample paths. The results obtained here are less restrictive than those of Luo [J. Math. Anal. Appl. 355, 414-425, 2009] and Govindan [Stochastics 77, 139-154, 2005].

M11: Teaching Undergraduate Mathematics, Part 2. *Alina Duca*, SAS 1216

Intensive Experiences for Undergraduate Mathematics

Presenter: *Suzanne Sumner* (ssumner@umw.edu), University of Mary Washington, Fredericksburg, Virginia

Students often leave mathematics courses performing the necessary calculations, yet with no deep understanding of the material. If assignments stress the communication of quantitative ideas, students must articulate the mathematics, and it becomes

clear whether they have a thorough understanding. Three intensive courses will be demonstrated: Learning by Exploring in Mathematics of Chaos first-year seminar; Learning by Writing in History of Mathematics; and Learning through Speaking in Introduction to Mathematical Modeling studying, environmental problems.

The Clemson SCALE - UP Experience in Calculus

Presenter: *Mark Cawood* (cawood@clemson.edu), Clemson University

Educational research indicates that students should collaborate on interesting tasks and be deeply involved with the material they are studying. Since the Fall 2006 Semester, the Department of Mathematical Sciences at Clemson University has taught its first- and second-semester calculus courses in tightly coordinated sections using a SCALE-UP model to promote active learning in redesigned classrooms that seat 45 students. The social interactions between students and their teachers appear to be the "active ingredient" that makes the approach work.

Just In Time Teaching using a Livescribe Smartpen

Presenter: *Brenda Burns-Williams* (bdburns@ncsu.edu), NC State University

In this session the workshop leader will demonstrate how presentations made with the Livescribe Smartpen can help students review prerequisite materials, reinforce key concepts that students often have trouble mastering, and review for tests.

C3: Contributed Session 3, SAS 2106

Optimal Control of Delay-Differential Inclusions in Infinite Dimensions

Presenter: *Dong Wang* (dwang@uncfsu.edu), Fayetteville State University, Fayetteville, North Carolina

Co-authors: *Boris Mordukhovich* (boris@math.wayne.edu), Wayne State University, Detroit, MI *Lianwen Wang* (lwang@ucmo.edu), University of Central Missouri, Warrensburg, MO

In this talk, we concerns the study of a general class of optimal control problems described by delay-differential inclusions with infinite-dimensional state spaces, endpoints constraints, and multivalued initial conditions. We develop the method of discrete approximations to derive necessary optimality conditions in the extended Euler-Lagrange form by using advanced tools of variational analysis and generalized differentiation in infinite dimensions. This method is fully realized in the delay-differential systems under consideration.

Parameter Estimation and Sensitivity Analysis for Parabolic Equations

Presenter: *Vitor Leite Nunes* (vitor@vt.edu), Virginia Tech

In this talk, we will formulate a parabolic parameter estimation problem. This includes storing the necessary conditions for optimality. One of these conditions includes the Frechet derivative, of the state equation with respect to parameter variations. We will outline our future strategy for computing this derivative, and present some preliminary results.

Sensor Location in Feedback Control of Heat Equation

Presenter: *Weiwei Hu* (huweiwei@vt.edu), Virginia Tech

The optimal sensor placement for purposes of feedback control is vital in order to obtain information necessary for accurate state estimation. A method for sensor placement for the heat equation in two dimensions is discussed. In particular, we show how feedback functional gains reflect spatial regions over which accurate information is paramount for control. We use this information in an algorithm which computes Centroidal Voronoi Tessellations, yielding optimal locations for sensors.

Normal Forms for Controlled and Stochastic Differential Equations

Presenter: *Boumediene Hamzi* (hamzi@math.duke.edu), Duke University

We propose a methodology to derive normal forms for nonlinear controlled and stochastic differential equations. This approach extends to systems with special structure (Hamiltonian, Lagrangian).

C4: Contributed Session 4, SAS 1220

A Posteriori Error Estimates of the Discontinuous Galerkin Method for Hyperbolic Systems

Presenter: *Thomas Weinhart* (t.weinhart@ewi.utwente.nl), University of Twente, The Netherlands,

Co-author: *Slimane Adjerid* (adjerid@math.vt.edu), Virginia Tech

A posteriori error estimates are a useful tool to verify the quality of finite element approximations and to control the error in adaptive meshes. We apply the discontinuous Galerkin method to first-order linear hyperbolic systems in two and three space dimensions. We explicitly write down the leading error term and solve local finite element problems to obtain a posteriori error estimates. We present convergence and numerical results for acoustic problems and the shallow water equations.

The Discontinuous Galerkin Method for Hyperbolic Problems on tetrahedral meshes: A posteriori Error Estimation

Presenter: *Idir Mechai* (mechaii@vt.edu), Department of Mathematics, Virginia Tech
Co-author: *Slimane Adjerid* (adjerids@vt.edu), Virginia Tech

We construct simple, efficient and asymptotically correct a posteriori error estimates for discontinuous finite element solutions of three-dimensional scalar first-order hyperbolic partial differential problems on tetrahedral meshes. We explicitly write the basis functions for the error spaces corresponding to the finite element space \mathcal{P}_p . The leading term of the discretization error on each tetrahedra is estimated by solving a local problem. The a posteriori error estimates are tested on several linear problems to show their efficiency and accuracy under mesh refinement for smooth solutions.

An application of Immersed Finite Elements to 1D Parabolic Equations with Moving Interface

Presenter: *Xu Zhang* (xuz@vt.edu), Virginia Tech
Co-authors: *Slimane Adjerid* (adjerids@math.vt.edu), Virginia Tech; and *Tao Lin* (tlin@math.vt.edu), Virginia Tech,

We will discuss an application of p-th degree immersed finite elements (IFE) to the moving interface problems of parabolic equations with discontinuous coefficients. The interface jump conditions are employed in the IFE functions, and the mesh need not to be aligned with the location of interface. So we can solve the problem on a fixed mesh even though the interface is moving. A fully discretized scheme based on the Crank-Nicolson idea will be presented. Optimal error estimates for this scheme have been obtained and numerical examples will be presented to illustrate the performance of this scheme.

SUNDAY, MARCH 21

09:00am - 10:00am Plenary Talk 3, *Ronald E. Mickens*, SAS 2203

New Class of SIR Models.

Ronald E. Mickens (rmickens@cau.edu)

Clark Atlanta University

Moderator: N. Medhin

Standard SIR epidemiological models have the property that the infectious population numbers only go to zero as $t \rightarrow \infty$. We demonstrate, by an explicit construction, that models can be formulated such that $I(t)$ becomes zero at a finite time. Both analytical and numerical results are given to support this conclusion. A general overview of the construction methodology for spread of disease models will be given.

10:00am - 10:30am Coffee Break

10:30am - 11:30am Plenary Talk 4, *Amy Langville*, SAS 2203

Ranking with Optimization Techniques

Amy Langville (langvillea@cofc.edu)

College of Charleston

Moderator: C. Meyer

I will present a rating method that, given information on the pairwise comparisons of n items, minimizes the number of inconsistencies in the ranking of those items. This Minimum Violations Ranking (MVR) Method, which is joint work with Kathryn Pedings and Yoshi Yamamoto, uses a binary linear integer program (BILP) to do this. We were able to prove conditions when the relaxed LP gives an optimal solution to the original BILP. In addition, the LP solution gives information about ties and sensitivities in the ranking.

11:30am - 01:00pm Lunch on your own

01:00pm - 03:00pm Parallel Sessions

M2: Control, Optimization, and Applications. *Negash Medhin* and *Robert White*, SAS 2106**Active Incipient Fault Detection With More Than Two Simultaneous Faults**

Presenter: *Martene Fair* (mlfair@unity.ncsu.edu), North Carolina State University

The problem of detecting small parameter variations in linear uncertain systems due to incipient faults, with the possibility of injecting an input signal to enhance detection, is considered. Most studies assume that there is only one fault developing. Recently, an active approach for two simultaneous faults has been introduced, but having more than two simultaneous incipient faults is sometimes the natural assumption. In this paper we extend this approach to allow for more than two concurrent faults. A computational method for the construction of an input signal for achieving guaranteed detection with specified precision is presented for discrete time systems. The method is an extension of a multi-model approach used for the construction of auxiliary signals for failure detection; however, new technical issues must be addressed. A case study is examined.

Study of Numerical Solution of Differential Game Models

Presenter: *Wei Wan* (wwan@claffin.edu), Claffin University, Orangeburg, SC

The applicability of a differential game model is decided by the solvability of the differential game. Thus, investigation of methods to solve differential game models is always active. Some differential game models in the literatures are simple such that they can be solved explicitly. However, generally, analytical method does not work well for high-dimensional models. In this presentation, numerical algorithms for differential game models will be presented. Furthermore, different types of differential game models, such as Stackelberg differential game, cooperative differential game, and stochastic differential game, have different optimality conditions, leading to different methods. The related algorithms and numerical results will be presented and discussed.

Convergence of a Nonlinear Least Squares Algorithm for Identification of Hazards

Presenter: *Robert E. White* (white@math.ncsu.edu), North Carolina State University

Given observations of selected concentration one wishes to determine unknown concentrations and locations of the sources for a hazard. The concentrations of the hazard are governed by a nonlinear diffusion-advection partial differential equation and the best fit of the data by numerical solution of the differential equation. This leads to a coupled nonlinear algebraic system and a nonlinear least squares problem. The coefficient matrix is a nonsingular M-matrix and is not symmetric. An iterative method is formulated and convergence is studied.

On The Control of Impulsive Hybrid Systems

Presenter: *N. G. Medhin* (ngmedhin@ncsu.edu), North Carolina State University

We consider a general class of impulsive hybrid systems with restrictions on the impulsive jumps, state and control between jumps. An objective functional, which takes into account, the history of the jumps explicitly over the time horizon of interest is considered. We characterize the optimal control and jumps. Applications are considered from production planning.

M3: Dynamics and Control, Part 3. *Dmitry Zenkov* and *Scott Kelly*, SAS 2102

Energy Efficiency and Wake Structure in Idealized Fishlike Swimming

Presenter: *Scott David Kelly* (scott@kellyfish.net), UNC Charlotte

Co-author: *Parthesh Pujari* (ppujari@uncc.edu), UNC Charlotte

Fishlike swimming relies on the shedding of vorticity from the deformable surface of an animal or vehicle to impart momentum to the surrounding fluid. The energy efficiency of a particular swimming gait is reflected in the distribution of vorticity in the shed wake. Employing an idealized model for the planar swimming of a variable-camber hydrofoil, according to which vortex shedding is restricted to a single point and dissipation is absent from the fluid, we examine the relationship between wake structure and swimming efficiency in both quiescent fluids and idealized schooling environments.

Optimizing Coordinate Choice for Locomoting Systems

Presenter: *Ross L. Hatton* (rlhatton@cmu.edu), Carnegie Mellon University

Co-author: *Howie Choset* (choset@scmu.edu), Carnegie Mellon University

Animals often use gaits – cyclic changes in shape producing a net displacement – to move through their environments. In robotics, we are interested in planning motions for artificial systems that can match or exceed the locomotive capabilities of animals. A fundamental question of locomotion is “What are the characteristics of a useful gait?” The geometric mechanics community has made significant progress in answering this question, identifying functions of the system shape that capture the net displacements induced by broad classes of gaits without having to individually test each possible motion. In this talk, we first introduce these results with the aim of separating them from the specialized language of differential geometry and making them accessible to a broader audience. Following this introduction, we then examine how the choice of generalized coordinates quality of the locomotion functions, a question which has not previously been addressed.

Swimming and Flapping in Vortex Wakes

Presenter: *Silas Alben* (alben@math.gatech.edu), Georgia Institute of Technology

We consider two problems related to the propulsion of flexible surfaces in vortex wakes. First, we present a simple model of a trout swimming in a cylinder wake, which save energy by slaloming through a vortex street. We find analytic solutions and compare with previous experiments and numerics. Second, we study “inverted drafting” in flags, in which the drag force on one flag is increased by excitation from the wake of another. The types of drafting and dynamics (synchronization and erratic flapping) depend on the separation distance between the flags.

Vortex Design Problem

Presenter: *Bartosz Protas* (bprotas@mcmaster.ca), McMaster University

We study the inverse problem of vortex design for 2D Euler flows characterized by vortex regions with constant vorticity. An approach is proposed in which a control input is determined so that the resulting vortex region has prescribed location and shape. The problem is formulated as PDE-constrained optimization in which the solutions are found using a gradient-based method. A key step is determination of the cost functional gradient which, recognizing the governing Euler system as a free-boundary problem, is obtained using methods of the shape-differential calculus.

M5: Mathematical Modeling of Biological Systems, Part 3. *Anita Layton*, SAS 2235

Multiscale Factor Models for Molecular Networks

Presenter: *Sayan Mukherjee* (sayan@stat.duke.edu), Duke University

A factor modeling framework is developed that is both predictive of phenotypic or response variation and the inferred factors offer insight with respect to underlying physical or biological processes. The method is general and can be applied to a variety of scientific problems. We focus on modeling complex disease phenotypes (etiology of cancer) as a motivating example. In this setting, the factors capture gene or protein interaction networks at different scales – breadth of the interaction network. The method integrates multiscale analysis on graphs and manifolds developed in applied harmonic analysis with sparse factor models, a mainstay of applied statistics.

A Predictive Mathematical Model of the DNA Damage G2 Checkpoint

Presenter: *Kevin Kessler* (kevin@kessler.net), University of North Carolina

A model of the transition from the G2 phase in the cell cycle to mitosis (M) was constructed from the known interactions of proteins that are thought to play significant roles in the G2 to M transition as well as the DNA damage G2 checkpoint.

Because the model was built from individual protein interactions it can be used to determine if the current understanding of the G2 checkpoint is sufficient to explain experimental observations of the checkpoint.

Coupled Poisson Processes for Wake-sleep Cycling

Presenter: *Badal Joshi* (joshi@math.duke.edu), Duke University

Mammalian infants show rapid switching between sleep and wake states. Based on the known neurophysiology, we suggest a simple biologically realistic mechanism and develop a mathematical model. The model incorporates three timescales: firing of action potential (approx. 1ms), sleep and wake bout times (seconds) and developmental time scale (days). The model predicts the correct statistics of occupancy times in sleep and wake states and the corresponding changes through development.

M8: Ranking and Clustering. *Chuck Wessell* and *Carl Meyer*, SAS 2203

A Comparison of Methods for Creating Similarity Matrices

Presenter: *Chuck Wessell* (cdwessel@ncsu.edu), North Carolina State University

When converting vector data into a similarity matrix, there are many measures to choose from, and many scaling ideas to use once the measure is chosen. Different options will be applied to a well-known data set (or data sets), and the results compared in the hope of gaining insight into what general principles should guide a researcher working with a new data set.

Preprocessing using Non-negative Matrix Factorization in Conjunction with K-means

Presenter: *Ralph Abbey* (rpwabbeyl@gmail.com), North Carolina State University

Non-negative Matrix Factorization (NMF) algorithms have been used for clustering and classifying data with increasing popularity in recent years. We use the versatility, and the dimension reducing aspects of the NMF, in combination with K-means, a widely used traditional clustering method, to improve clustering, as well as reduce storage. The results show improved accuracies of clustering when compared to either K-means or NMF alone for clustering.

Minimum Weight k-Cliques in Cluster Aggregation

Presenter: *Tori Ellison* (vmelliso@edisto.cofc.edu), College of Charleston

Several cluster aggregation algorithms are proposed, evaluated, and compared against other cluster aggregation methods. One proposed algorithm first finds a minimum weight k-clique of the graph of a set of n clustering assignments. The nodes in this k-clique serve as cluster representatives for the k desired clusters and pull in the remaining nodes to a well-suited cluster in the second part of the algorithm.

When a win is not a win - Inducing Ties in Sports Ranking

Presenter: *Erich Kreutzer* (erkreutzer@davidson.edu), Davidson College

Pretend the score is 14 to 14 as your field goal kicker steps onto the field to attempt a 40 yard field goal to win the game. As the clock ticks down, he makes the field goal to win 17 to 14. After a majority of the game had been played you were tied with the other team. What if we count this and all games within 3 points as ties? In this presentation we will look to see how to include ties in sports ranking methods such as the Colley Method and Massey Method. Then we will see how counting wins as ties affects the ranking algorithms.

The Probability of Winning College Basketball Games

Presenter: *Ryan Parker* (rjparker1@edisto.cofc.edu), College of Charleston

In this problem we consider how to rank college basketball teams so that we can estimate the probability of a team winning postseason games. To do this, we consider two models of college basketball's points per possession data: a linear regression and a multinomial logistic regression. These models allow us to estimate the probability of winning future games, and we will show how they perform in predicting postseason games.

M9: Stochastic Analysis and Financial Mathematics. *T.Pang* SAS 1218**Momentum Trading under a Regime Switching Model**

Presenter: *Qing Zhang* (qingz@math.uga.edu), University of Georgia

This talk is concerned with the optimality of a trend following trading rule. The idea is to catch a bull market at its early stage, ride the trend, and liquidate the position at the first evidence of the subsequent bear market. We characterize the bull and bear phases of the markets mathematically using the conditional probabilities of the bull market given the up to date stock prices. The optimal buying and selling times are given in terms of a sequence of stopping times determined by two threshold curves. Numerical experiments are conducted to validate the theoretical results and demonstrate how they perform in a marketplace.

Some Recent Results on Switching Diffusion Processes

Presenter: *George Yin* (gyin@math.wayne.edu), Wayne State University

In this talk, we review some of our recent results on switching diffusion processes. Some applications to stochastic control and differential games will also be mentioned.

Minimizing Conditional Value-at-Risk under Constraint on Expected Value

Presenter: *Mingxin Xu* (mxu2@unc.edu), UNC Charlotte

This talk gives a complete solution to the problem of the type

$$\inf_{X \in \mathcal{F}} E[(x - X)^+] \quad (1)$$

$$\text{subject to } E[X] \geq z, \quad \tilde{E}[X] = x_r, \quad x_d \leq X \leq x_u \text{ a.s.} \quad (2)$$

where the constants satisfy $-\infty < x_d < x_r < x_u \leq \infty$, $x \in \mathbf{R}$, $z \in \mathbf{R}$. The expectations $E[\cdot]$ and $\tilde{E}[\cdot]$ are taken under two equivalent probability measures P and \tilde{P} under the assumption that the Radon-Nikodým derivative has a continuous distribution. The result is then used to find the optimal dynamic portfolio which minimizes the Conditional Value-at-Risk in a complete market model.

Risk Management in Portfolio Optimization

Presenter: *Song Yang* (syang2@ncsu.edu), NC State University

Portfolio optimization problem is one of the hot topics in risk management. In this talk, we are looking into the portfolio optimization problem with Conditional Value-at-Risk (CVaR) as the risk measurement. Our objective is to minimize the CVaR of the portfolio under certain constrains. Coupla based credit and market risks have been taken into consideration. Further, we consider a time series heteroscedastic model under the ARMA-GARCH framework for this optimization problem. We will find the efficient frontier for the portfolio with the marginal distribution of each asset to be generalized skewed t (GST) distribution. It has be found that the serial of optimal CVaR we obtained from time series model describes the real world's market risk very efficiently.

C5: Contributed Session 5, SAS 2229

Existence Theorem for a quasilinear Poisson equation

Presenter: *Timur Milgrom* (tm454@drexel.edu), Drexel University

Co-author: *David Ambrose* (ambrose@math.drexel.edu), Drexel University

A quasilinear Poisson equation is considered where the nonlinearity has a special type of decomposition. We will consider the equation with Dirichlet, Neumann and mixed boundary conditions. The existence and uniqueness of a periodic solution using a fixed point argument will be shown. Finally we will provide an example of an equation which has such decomposition and satisfies the analysis.

A Boundary Value Transformation for an Inverse Source Problem for the Poisson Equation

Presenter: *Dmitry Glotov* (dglotov@auburn.edu), Auburn University

We consider an inverse problem for the Poisson equation with point sources in dimension two. The data is given in the form of the boundary values of the absolute value of the gradient and its derivatives. We present a method for converting the boundary data of this type into the boundary data of a linear type. The method allows us to establish uniqueness for this problem in the presence of an additional constraint.

Energy and Hamiltonian Properties of Graphs

Presenter: *Rao Li* (raol@usca.edu), University of South Carolina Aiken

The eigenvalues of a graph are the eigenvalues of its adjacency matrix. The energy of a graph is defined as the sum of the absolute values of the eigenvalues of the graph. Sufficient conditions based on the energy for some Hamiltonian properties of graphs will be presented in this talk.

Householder Computation of Sparse Matrix Singular Values

Presenter: *Gary Howell* (gary_howell@ncsu.edu), NCSU

This talk introduces block Householder reduction of a rectangular sparse matrix to small band upper triangular form. The computation accesses a sparse matrix only for sparse matrix dense matrix (SMDM) multiplications and for “just in time” extractions of row and column blocks. For a bandwidth of $k + 1$, the dense matrices are the k rows or columns of a block Householder transformation. Using an initial random block Householder transformation allows reliable computation of a collection of largest singular values.

Block Householder reduction is numerically stable, is computationally efficient on multicore cache based computer architectures, and has good potential for scalable distributed memory parallelization.

C6: Contributed Session 6, SAS 2225

The Dynamics of an Immersed Droplet in Viscoelastic Fluids

Presenter: *John Crispell* (jchrispe@tulane.edu), Tulane University

Co-authors: *Lisa Fauci* (ljf@math.tulane.edu), and *Ricardo Cortez* (cortez@math.tulane.edu), Tulane University

Many biological fluids are viscoelastic and require a nonlinear constitutive equation to describe the evolution of the extra-stress tensor. Using an immersed boundary framework we model the movement of immersed elastic boundary interacting with a surrounding viscoelastic fluid. We present recent results on dynamics of a closed membrane moving under surface tension.

Acute Inflammatory Response to Endotoxin Challenge: A Reduced Model Development and Parameter Estimation

Presenter: *Dennis .O. Frank* (dofrank@ncsu.edu), North Carolina State University
Co-authors: *Hien .T. Tran* (tran@math.ncsu.edu), North Carolina State University

In general, mathematical models of biological processes are described by highly nonlinear dynamic systems of differential equations with relatively large number of parameters. Roy et al. had previously developed an 8-state ordinary differential equation (ODE) model of acute inflammatory response to endotoxin challenge. Endotoxin challenges were administered to rats, and experimental data for pro- and anti-inflammatory cytokines were obtained. In this work, we proposed a reduced ODE model; while preserving the underlying biology. Both models were calibrated to the experimental data. Model comparison, and validation were done by comparing curve fitting of the original 8-state model and the reduced model against experimental data, and by using Akaike's Information Criterion.

Population Ecology: A Linear Algebra Supplement

Presenter: *Brian Bradie* (bbradie@cnu.edu), Christopher Newport U., VA

The field of population ecology offers a rich source of applications for many of the fundamental tools of linear algebra. Eigenspace calculations determine population growth rates, stable age distributions and reproductive values. The scalar product and matrix multiplication can be used to construct sensitivity and elasticity matrices that measure the influence of demographic parameters on the growth rate. Moreover, information pertaining to life expectancies and net reproductive rates can be obtained from the matrix inverse. Sources for real demographic parameter sets will be discussed.

Dynamically-Consistent Non-Standard Finite Difference (NSFD) Method for a HIV Vaccine Model

Presenter: *Salisu M. Garba* (garba@cc.umanitoba.ca), University of Manitoba, Canada

The paper presents two finite-difference methods for numerically solving a deterministic continuous-time model arising in population biology. The central objective is to determine which of the two methods give solutions that are dynamically-consistent with those of the continuous-time model. The first method, a standard implicitly-derived explicit finite-difference method, is shown to suffer numerous scheme-dependent instabilities (such as convergence to false steady-state solutions, failing to preserve many of the main essential dynamical features of the model including positivity invariance, backward bifurcations, etc.), particularly when relatively large step-sizes are used in the simulations. On the other hand, the second method, constructed based on Mickens' non-standard finite-difference discretization, is shown to be free of any of the aforementioned instabilities and contrived behaviour regardless of the size of the step-size used in the numerical simulations. In other words, unlike the first method, the non-standard method is dynamically-consistent with the original continuous-time model.

C7: Contributed Session 7, SAS 1220**Asymptotic Analysis of the Shape and Composition of Alloy Islands in Epitaxial Solid Films**

Presenter: *Mihaela Blanariu* (mblanariu@colum.edu), Dept. of Science and Mathematics, Columbia College Chicago, IL

Co-authors: *B. J. Spencer* (bspencer@buffalo.edu), Dept. of Mathematics, State University of New York at Buffalo, NY,

We consider the formation of solid drops (islands) occurring in the growth of strained solid films. Beginning from a detailed model for the growth of an alloy film that incorporates the coupling between composition, elastic stress and the morphology of the free boundary, we develop an asymptotic description of the shape and compositional non-uniformity of small alloy islands grown at small deposition rates. The system can be decomposed into two parts: one part gives the shape analogous to that obtained for a single-component island determined by Shanahan and Spencer (2002), and the other part gives the composition profile in terms of the shape. The shape of an alloy island is identical to that of a single-component island with the same system parameters, but with a non-uniform composition that depends on the stress-composition coupling and alloy solution thermodynamics. We describe the structure and magnitude of the compositional non-uniformity and interpret our theoretical results in the context of SiGe films.

The Rapid Advance and Slow Retreat of a Mushy Zone

Presenter: *Nicholas Gewecke* (gewecke@math.utk.edu), University of Tennessee

Co-author: *Tim Schulze* (schulze@math.utk.edu), University of Tennessee

Mushy zones are regions of intermixed liquid and solid which most often result from instability due to the build-up of solute during the solidification of multispecies materials. If the diffusion of the solute is ignored in the model then there is a steady state mushy zone, representative of what is observed over typical laboratory time scales, but even a small amount of diffusion causes the mushy zone to retreat and eventually vanish over a much longer timescale.

Wave Propagation in Imperfectly Periodic Structures

Presenter: *Yuri A. Godin* (ygodin@uncc.edu), UNC at Charlotte

Co-authors: *Stanislav Molchanov* (smolchan@uncc.edu), and *Boris Vainberg* (brvainbe@uncc.edu), UNC at Charlotte

We study the influence of disorder on the wave propagation in periodic structures. Exact dependence of the Lyapunov exponent is established as a function of wave frequency and strength of disorder. We show that the Lyapunov exponent has completely different behavior depending on whether the frequency is located in the bulk of the band or near a band edge. In the latter case, small disorder drastically reduces transmission of the waveguide.

C8: Contributed Session 8, SAS 1102**On FEM Approximations to the Navier-Stokes Equations with Scott-Vogelius Elements**

Presenter: *Michael Case* (case@clemson.edu), Clemson University

Co-authors: *Vince Ervin* (vjervin@clemson.edu), Clemson University; *Alexander Linke* (linke@wias-berlin.de), Weierstrass Inst. for Applied Analysis & Stochastics; and *Leo Rebholz* (rebholz@clemson.edu), Clemson University

Under a mild mesh restriction, $(X_h, Q_h) = (P_k, P_{k-1}^{disc})$ element pairs have recently been shown to be inf-sup stable for $k \geq d$. Since $\nabla \cdot X_h \subset Q_h$, the usual weak mass conservation equation implies strong mass conservation, which has several important consequences. In this talk, we will compare NSE simulation results of this element pair against those obtained from more commonly used element pairs.

Discontinuous Galerkin methods with entropy variables and explicit time integrators: A numerical study with the shallow water equations

Presenter: *Cory D. Hauck* (hauckc@ornl.gov), Oak Ridge National Laboratory

Co-author: *Robert D. Lowrie* (lowrie@lanl.gov), Los Alamos National Laboratory

We investigate discontinuous Galerkin methods for conservation laws that use entropy variables to generate entropy-stable schemes. Unfortunately, the fully discrete scheme is fully implicit, often making it prohibitively expensive. For the shallow water equations, we investigate schemes that use explicit time integrators and solve convex optimization problems to find local expansion coefficients. Such schemes fit squarely into the emerging paradigm of data-parallel computing, since the optimization algorithm can be managed by local processing units.

Existence of Minimum Action Curves: A Reformulation of the Quasipotential

Presenter: *Matthias Heymann* (heymann@math.duke.edu), Duke University

I study a class of action functionals $S(\gamma)$ on the space of unparameterized oriented rectifiable curves γ in R^n . Denoting $\Gamma_{A_1}^{A_2} := \{\gamma \mid \gamma \text{ starts in } A_1 \text{ and ends in } A_2\}$ for two given sets $A_1, A_2 \subset R^n$, I develop criteria under which there exists a curve $\gamma^* \in \Gamma_{A_1}^{A_2}$ such that $S(\gamma^*) = \inf\{S(\gamma) \mid \gamma \in \Gamma_{A_1}^{A_2}\}$. Among other applications, a reformulation of the quasipotential of Freidlin-Wentzell theory (a subfield of large deviation theory) is presented that fits into this context, thus proving the existence of a “maximum likelihood transition curve.”

Modelling Tubuloglomerular Feedback in Nephrons

Presenter: *Nathaniel Whitaker* (whitaker@math.umass.edu), University of Massachusetts

Tubuloglomerular feedback (TGF) is a delayed negative mechanism which stabilizes the glomerular filtration rate (renal blood flow) and salt concentration in a single nephron, the basic filtering unit of the kidney. Earlier models indicate that the TGF mechanism plays a role in the mediation of constant flow rate and limit cycle oscillations. However, these models did not incorporate the influence of backleak (diffusion). This talk examines the effects of backleak on a single and on coupled nephrons. The main result is that backleak stabilizes the system. We present the basic equations and the stability analysis for the governing equations. Numerical methods are developed and implemented to study predictions given by the bifurcation analysis of the equations.

03:00pm Conference Ends