AWM Triangle Conference 2018

Schedule and Abstracts

February 17, 2018

Graduate Research Talks I

Session I: Small scale fluid mechanics–Phillips Hall 328

10:00-10:15 Sarah Ritchey (Duke University)

Title: Modeling blood flow with the opened immersed interface method.

Abstract: Blood flow can be modeled as a fluid-structure interaction problem. The presence of a blood vessel immersed within a fluid domain causes the pressure to be discontinuous and the fluid velocity to be non-smooth. The immersed interface method (IIM) incorporates discontinuities in the velocity gradient and pressure into finite difference approximations for discretized Stoke's equation. I will discuss the extension of IIM to model an immersed interface shaped like an open tube that better represents blood vessels.

10:20-10:35 Weifan Liu (Duke University)

Title: Modeling thin film evolution in response to fluxes

Abstract: Thin films of viscous fluids on hydrophobic surfaces are unstable and dewet to form droplets. The droplets move and change mass in response to fluxes on slow time scales. In one-dimension, the evolution of droplets can be approximated by a system of ordinary differential equations. We develop an improved differential equation model for a single droplet on a finite domain. We show that the improved model produces a more accurate prediction of the single-droplet pressure and position compared to the previous model.

10:40-10:55 Holly Arrowood (UNC Chapel Hill)

Title: An experimentally-validated first-principles of an oil droplet rising through sharply-stratified fluid

Abstract: A drop of immiscible fluid rising through two density-stratified, miscible fluid layers slows to below terminal velocity due to the deformation of the fluid density field. We present a numerically-assisted analytic model of this effect, coupled with an experimental study in the Stokes regime using oil drops rising in stratified glycerol.

Session II: Numerical methods and data analysis–Phillips Hall 332

10:00-10:15 Ashleigh Thomas (Duke University)

Title: Topological Feature Extraction for Data Analysis

Abstract: Feature extraction is a data processing technique that picks out the important information from data sets that are otherwise too large and complicated to work with. In this talk we will introduce feature extraction and then focus on a topological feature extractor called persistent homology. We will explore features from an evolutionary biology data set and discuss an important aspect of designing a feature extractor: choosing features that lend themselves to statistical analysis.

This talk should be accessible to undergraduates with little to no advanced mathematical experience.

10:20-10:35 Yanni Lai (UNC Chapel Hill)

Title: Multigrid Solver for Steady Stokes System with Variable Density and Viscosity

Abstract: I investigate the projection preconditioner for solving the variable-coefficient Stokes system with incompressible flow and periodic boundary condition. The system is discretized using second-order finite difference scheme. I consider block-factorization in the numerical implementation and apply projection method as the preconditioner for GMRES. Multigrid solvers with Gauss-Seidel smoother are implemented independently for the velocity and pressure subproblems. In the test problem, the optimal rate of convergence of GMRES is observed with using only a single V cycle in the proconditioner, showing the efficiency of this solver for large-scale computations.

10:40-10:55 Hayley Guy (NCSU)

Title: Using active subspaces to model biotransport in tumors with uncertain material properties

Abstract: We consider modeling biotransport in tumors with uncertain heterogeneous material properties. Specifically, we consider uncertainties in the permeability field, which we model as a log-Gaussian random field. Our goal is to understand the uncertainties in pressure distribution in the tumor. This is a difficult problem due to high-dimensional input parameter space. In this problem we focus on studying the pressure at the site of injection. We use active subspaces to reduce the dimension of the parameter space and then exploit them to build a surrogate that models the average pressure at the center of the tumor.

Session III: Trees and graphs–Phillips Hall 367

10:00-10:15 Ella Pavlechko (NCSU)

Title: On Determining if Tree-based Networks Contain Fixed Trees

Abstract: In a previous paper by Francis and Steel, they give a polynomial time algorithm to decide if a phylogenetic network, N, is tree-based. They then ask if given any fixed tree T and network N, can it be decided in polynomial time whether N is based on T? We are able to show that such an algorithm would be NP-hard, and that the problem itself is fixed-parameter tractable. This is joint work done as part of the Treespace REU at Lehman College, CUNY.

10:20-10:35 Ran Huo (Duke University)

Title: Latent Voter Model on Locally Tree-like Random Graphs

Abstract: In the latent voter model, which models the spread of a technology/opinion through a social network, individuals who have just changed their choice have a latent period, during which they will not buy a new device. We study site and edge versions of this model on random graphs with bounded degrees. Given two opinions 0 and 1, we show that if time is sped up then the fraction of each opinion converges to an ODE which converges to $1/2$ as $t \to \infty$. As a result, the latent voter model has a quasi-stationary state in which opinion 1 has probability $\approx 1/2$ and persists in this state for a time $> n^p$ for any $p < \infty$. Thus, even a very small latent period drastically changes the behavior of the voter model.

10:40-10:55 Molly Lynch (NCSU)

Title: Crystal posets and the weak order

Abstract: We define a crystal graph and state certain relations that occur amongst crystal operators. We can view these crystals graphs as a partially ordered set. There is a poset map, namely the (right) key map, from a crystal poset to the weak order on the corresponding Weyl group. We explore which well known properties of the weak order can be lifted to crystal posets.

Session IV: Applications of pure mathematics concepts–Phillips Hall 381

10:00-10:15 Katharine Ahrens (NCSU)

Title: Lattice-based Cryptography: An Introduction

Abstract: Lattice-based hard problems are a leading candidate for implementation in future cryptographic schemes due to their conjectured quantum resilience. In this talk, we give an overview of past attempts to approach the shortest vector problem (SVP) algebraically in a class of lattices generated by principal ideals in the cyclotomic integers. We conclude by describing the beginnings of our research in related areas, including exploring cryptographic hardness of the SVP in principal ideals generated over Kummer extensions.

10:20-10:35 Trinity White (UNC Wilmington)

Title: Modeling Art in Mathematics

Abstract: For the 2016 Summer Games of XXXI Olympiad, Anthony Howe created a kinetic wind sculpture for the cauldron. This sculpture and the pieces appeared to swirl. Upon closer inspection the shape made by the movement could be viewed as a twisted torus. We model this shape using a mathematical structure called a Hopf Fibration, which can be visualized through the projection of a three-sphere, S3, in four dimensions onto a two-sphere, S2, such as the surface of a ball.

Graduate Research Talks II

Session V: Mathematical biology and disease spreading–Phillips Hall 328

2:30-2:45 Ivanti Galloway (Wake Forest University)

Title: Measuring the Cost of Avoiding Vaccinations

Abstract: On April 10, 2017, The Minnesota Department of Health received notice about a suspected measles case in an unvaccinated child. On April 11th there was a second report of the measles. On April 13th a third case of measles was confirmed. By May 31, 2017 65 cases of the measles, an infectious disease thought to be eliminated in the United States, were confirmed. This outbreak occurred in area with a low vaccination rate. Improvements in medical care have far removed many in United States from risks of such infectious diseases. Consequently, this removal of certain death has given way to the anti-vaccination movements as well as the idea of spacing out vaccinations. In this research we investigate a system of ordinary differential equations that model the effect of anti-vaccination groups on the spread of infectious diseases, such as the measles, in a society as well as quantify the cost of vaccination and disease impose on a society.

2:50-3:05 Samantha Moore (UNC Chapel Hill)

Title: Predicting Network Dynamics based on Neural Connectivity

Abstract: Many networks in the brain exhibit patterned activity that does not reflect changes in external stimuli, but rather is generated intrinsically by the network itself. Past efforts to model and explain the full range of behaviors have involved a variety of complex ingredients making the models mathematically intractable. In this presentation, we focus on a new minimal model whose dynamics are driven solely by an underlying directed connectivity graph. This model is simple enough to be mathematically tractable but displays the full variety of internally-generated behaviors. Through this model, we intend to determine how neural connectivity shapes network dynamics.

Session VI: Representations of Lie algebras–Phillips Hall 332

2:30-2:45 Suzanne Crifo (NCSU)

Title: Maximal Dominant Weights for Representations of Affine Lie Algebras

Abstract: Affine Lie algebras are infinite dimensional analogs of finite dimensional simple Lie algebras. In this talk we will focus on determining the weights for a certain representation of the affine Lie algebra $B_n^{(1)}$. The set of weights is an infinite set. However, the set of maximal dominant weights is a finite set. Knowing this finite set of maximal dominant weights, we can determine other weights. Then our goal will be to determine the set of maximal dominant weights in this case.

2:50-3:05 Anila Yadavalli (NCSU)

Title: A representation theoretical approach to soliton solutions

Abstract: Integrable hierarchies arise from adding infinitely many commuting symmetries to an equation that models a physical process. Some classical examples are the Kadomtsev Petviashivili (KP), Toda, and Nonlinear Shrödinger (NLS) hierarchies. Such hierarchies admit soliton solutions which can be constructed in several ways. In this talk, we will show how the representation theory of infinite dimensional Lie algebras can be used to find soliton solutions to the NLS hierarchy. These are results were introduced in Victor Kac's *Infinite Dimensional Lie Algebras*.

Session VII: Algebraic geometry–Phillips Hall 367

2:30-2:45 Chen Shen (UNC Chapel Hill)

Title: A brief introduction to Hitchin systems

Abstract: The Hitchin system is an integrable system on the cotangent bundle of the moduli space of stable vector bundles on a Riemann surface. I will give a gentle introduction to it by describing the Hitchin map, which assigns each Hitchin pair to a point in the Hitchin base, and finally try to illustrate the geometry of this fibration.

2:50-3:05 Kate Pearce (NCSU)

Title: Multi-Polynomial Resultants

Abstract: The resultant can be thought of as "a general tool [with which we] control the modular images of the gcd" (von zur Gathen 152). In this talk, I will give some background for the usual Sylvester resultant of two polynomials in a single variable and then generalize Sylvester resultants to define resultants for $n + 1$ polynomials in n variables (or equivalently for $n + 1$ homogeneous polynomials in $n + 1$ variables). After introducing the definition and properties of these multi-polynomial resultants, I will outline the proposition that the resultant of such a polynomial system is zero if and only if the system has a common root with complex coordinates not all zero and briefly describe its proof. Finally, I will discuss some of the applications of resultants to implicitization problems and describe some specific constructions of multipolynomial resultants as matrices.

Session VIII: Mathematics education and outreach–Phillips Hall 381

2:30-2:45 Katie D. Bowman (Appalachian State University)

Title: Gender Differences in Cognitive Processes in Problem Solving

Abstract: Understanding the cognitive processes employed by students in problem solving is of practical importance. Further, it is important that there is an understanding of consistencies and differences in these problem-solving processes. This study investigated differences in cognitive processes in mathematical problem solving and whether the differences could be ascribed to gender. Investigations of gender and problem solving tend to focus on problem completion in terms of success or failure without dissecting the process by which they navigated the problem. The result of the study suggests that more data needs to be collected before gendered statements can be made about any similarities or differences in these processes. Although some differences were seen when comparing genders, there were also some noted consistencies. The findings of this study also provide implications that students who have completed higher level mathematics courses do not necessarily exhibit higher level problem-solving skills.

2:50-3:05 Francesca Bernardi (UNC Chapel Hill)

Title: Association for Women in Mathematics Mentoring Network - Supporting Female Mathematics Majors throughout their Undergraduate Career

Abstract: The Association for Women in Mathematics chapter at the University of North Carolina at Chapel Hill organizes a Mentoring Network, pairing graduate student mentors with undergraduate student mentees. The program has several goals, including helping participants navigate undergraduate education, guiding students through the transition to graduate school or the job market, providing undergraduates with role models, and fostering a diverse and supportive community in the department. The network is set up after a Speed Mentoring event where undergraduate students are invited to meet the available mentors and briefly chat with each one of them. Different students have different criteria for choosing a mentor, and by allowing them to meet the mentors beforehand, we try to accommodate everyone's preference. Some undergraduate students have found sharing a mentor with another mentee to be beneficial: this helps create a community of peers even among students at different stages in their undergraduate education. Both male and female mentors are part of the network, while so far all mentees have been female. Analysis of feedback from last year's network will be presented.

3:10-3:25 Katrina Morgan (UNC Chapel Hill)

Title: Inquiry-Based Learning Problem Sets in an Outreach Program for High School Girls: Increasing Confidence and Strengthening Interest Among Underrepresented Groups

Abstract: Inquiry-based learning is implemented in Girls Talk Math, a free summer day camp for high schoolers who identify as girls and are interested in math held at the University of North Carolina at Chapel Hill. IBL helps accomplish two program goals: increasing confidence and strengthening interest in taking college math courses. In IBL students feel ownership of their work, which increases confidence. IBL's emphasis on creative problem solving tends to be more engaging and interesting than the algorithmic approach often taken in high school courses. Increased engagement and interest is expected to improve the likelihood of participants pursuing further math. During camp, participants break into 8 groups of 4-5 campers to complete a lengthy problem set on a math topic usually not encountered until college or graduate school. Problem set topics include: Elliptic Curve Cryptography, Special Relativity, Scientific Computing, Fluid Dynamics, and Knot Theory. Team Leaders provide guidance, but campers decide how to spend their time and are responsible for their learning. Each group writes a blog post about the math they learn, allowing participants to assimilate new knowledge through reflection and communication.

Undergraduate Poster Session
3:30-4:00 in Phillips Hall 365

Lauren Murray (Appalachian State University)

Title: Analyzing Women Mathematicians in TV and Film: A Preliminary Discussion

Abstract: The purpose of this project is to understand the ways in which we can judge representations of women doing mathematics in both television and film. This requires creating a rubric and creating a data set to analyze and make conclusions. This is a preliminary discussion about the methods of this project, describing potential problems with data validity and introducing bias into data. With this initial discussion, we hope to facilitate an open conversation about methods of data collection and analysis related to the overall goals of this project.

Clara Schwamm (UNC Chapel Hill)

Title: Underrepresentation of Male Math Teachers of Color in K-12 Schools

Abstract: The number of male teachers of color in K-12 schools in the United States is exceedingly limited, even in predominantly non-White schools. These ratios are reduced even further when partitioned into content area. Several factors contribute to this severe underrepresentation, including: the school to prison pipeline (the tendency of students of color and students with exceptionalities to be punished, and even arrested, for discipline problems more than their white peers), the exploitation of black and brown students at the pre-postsecondary level (especially in high schools), the systematic dismantling of historically black colleges and universities, and the lack of representation itself. As representation is cyclical, these factors must be addressed in order to avoid further disappearance of male teachers of color.

Kaylee Stanton (UNC Chapel Hill)

Title: An Introduction to the Musical Plane

Abstract: Using pitch and time as the basis for a two-dimensional plane, composers and other artists can create auditory symmetry and transformations with melodies. These patterns can be analyzed on their own, or as a group which provide alternative representations for familiar topological surfaces. Adding on an additional layer by comparing tonality to color patterns allows for further study and appreciation of already fantastic pieces.

Victoria Whitley (UNC Chapel Hill)

Title: Constructing a Multi-Probe Conductivity Meter with Raspberry Pis

Abstract: Standard conductivity meters can only measure one probe at a time, often without recording the data they gather. The objective of this project was to find a cost effective and efficient way to measure the conductivity of several solutions at once. One Raspberry Pi connects to three conductivity circuits through wiring, and each circuit connects to its own probe and isolator. Coding through the raspberry Pi allows for a program that can poll each probe one after another at standard intervals of time. It can also record the data into a table saved on the pi that can be accessed whenever it is needed. For the cost of one standard conductivity meter, the device effectively does the work of six, as well as much more for long-term projects. Building this device can be easily replicated and allows for a more economic and comprehensive system of meters.

Eileah Zugger (UNC Chapel Hill)

Title: NIM on a Network

Abstract: The game of NIM is a strategy game played by two players. Historically, it involves a specific number of objects being removed from distinct piles. In this project, I look at how the game would be played on a network made up of nodes and edges. The rules are as follows: given any finite graph, players take turns removing either an edge or a node with all attached edges; the last player to remove a node wins the game. The purpose of my project is to determine which player will win the game given only what the network looks like, and who goes first. Using a divide and conquer strategy along with information about the original game, I found a way to determine the winner for almost all networks. My results show that if the method used for winning smaller portions of the larger network is known, the winner of the total game can be found with four steps of algebra.