Texas Women in Math Symposium 2020

Texas A&M University

February 1-2, 2020

Schedule for Contributed Talks on February 1, 2020

TIME	ROOM **A**	ROOM **B**	ROOM **C**
2:30 - 2:55 PM	Abigail Rose Ballard	Jane Long	Carlynn Fagnant
3:00 - 3:25 PM	Prajakta Bedekar	Kayla Coffey	Kari Eifler
3:30 - 3:55 PM	Samreen Khan	Xiaonan Xu	Thilini Vasana Mahanama
4:00 - 4:30 PM	**COFFEE BREAK**		
4:30 - 4:55 PM	Yan Li	Patricia Alonso Ruiz	Sarah Chehade
5:00 - 5:25 PM	Samiha C Rouf	Jingbo Liu	Hongwei Wang

Abstracts

Plenary Talks

- **Irene Gamba**, University of Texas at Austin
  Complex particle systems, collisions, billiards and dissipative mechanisms

  We discuss the mathematical properties of billiard models for monoatomic gases for a varied range of intermolecular potentials in terms of their binary collisional properties. An statistical framework associated to probabilistic consideration gives rise to dissipative mechanisms that lay a framework for connecting statistical with continuous mechanics by linking a properly scaled Boltzmann transport flow to classical fluid dynamics models. Such Statistical fluid models have applications that range from rarefied gas dynamics for a single specie, to mixture of monoatomic gases with disparate masses, to charge transport in plasmas as much as modeling of hot electron transport in semiconductor devices.

- **Raegan Higgins**, Texas Tech University
  Modeling on Time Scales

  Progress continues to be made in the unification and extension of discrete and continuous analysis since Stefan Hilger's milestone paper in 1988. The broad idea is to prove a result once for a dynamic equation where the domain of the unknown function is a time scale $\mathbb{T}$, which is an arbitrary, nonempty, closed subset of the real numbers. In this talk, we will introduce the theory of time scales using the exponential function. We will then give an overview of some current applications of time scales. Of particular interest are problems arsing in mathematical biology. Preliminary results on the development of certain models and the related analysis will be discussed.

Contributed Talks

- **Abigail Rose Ballard**, Tarleton State University
  Parameter Estimation and Simulation of Bacteriophage Infection Model

  Bacteriophages are a class of viruses that infect and destroy bacteria. For this reason, they are an emerging focus in research due to their potential use in treating antibiotic resistant bacterial infections. Tarleton State University, as part of the international HHMI SEA-PHAGES bacteriophage discovery program, is working on an interdepartmental project between the biology and mathematics departments to create a mathematical model for the complexity of bacteriophage infection of host cells. A system of $4n + 1$ differential equations were derived to model these interactions. This system of equations was then used to simulate results for the infection outcomes of the different populations. These results were then evaluated in search of equilibria for populations in a given parameter space. It is our hope that these simulated equilibria can be used to identify infection outcomes for bacteriophages used in clinical settings to speed up testing before usage and effectively improve patient outcomes.

- **Prajakta Bedekar**, University of Houston
  Modeling cellular differentiation using Reaction-Diffusion Equations

  Reaction-diffusion equations help model pattern formation through interactions of chemicals. Alan Turing used these systems to model cellular differentiation. In this talk, I will describe how we arrived at a set of realistic boundary conditions for this model, and how the experimental results validate our simulated model.

- **Sarah Chehade**, University of Houston
  Saturating the Data Processing Inequality for $\alpha - z$ Rényi Relative Entropy

  In Quantum Information Theory, one of the most famous inequalities is called the Data Processing Inequality (DPI). The inequality states that two quantum states become harder to distinguish after they pass through a noisy quantum channel. This inequality holds for a number of distinguishability measures, with the most basic one being the Umegaki relative entropy otherwise known as the quantum relative entropy. We are interested in the case of saturation of DPI for these measures. In this talk, I will review the problem, various generalizations of quantum relative entropy, and known results concerning DPI for them. Moreover, I will present a necessary and a sufficient condition for saturation of DPI for one of the generalizations for the Umegaki relative entropy called the $\alpha - z$ Rényi relative entropy. Both conditions are similar to the original condition of recoverability for quantum relative entropy, and coincide when $\alpha = z$, leading to a so-called sandwiched Rényi relative entropy. This is an joint work with Dr. Anna Vershynina.

- **Kayla Coffey**, Stephen F. Austin State University
  Ordered Ramsey Numbers for infinite families of graphs

  An ordered graph H on n vertices is a graph whose vertices have been labeled bijectively with $\{1, \ldots, n\}$. The ordered Ramsey number $r(H)$ is the minimum n such that every two-coloring of the edges of the complete graph K_n contains a monochromatic copy of H such that the vertices in the copy appear in the same order as in H. Although some bounds on the ordered Ramsey numbers of certain infinite families of graphs are known, very little is known about the ordered Ramsey numbers of specific small graphs. In this talk we give non-trivial upper bounds on orderings of graphs on four vertices. We also use a SAT solver to compute some numbers exactly.

- **Kari Eifler**, Texas A&M University
  Non-local games and the graph isomorphism game

  Non-local games give us a way of observing quantum behaviour through the observation of only classical data. The graph isomorphism game is one such non-local game played by Alice and Bob which involves two finite, undirected graphs. A winning strategy for the game is called quantum if it utilizes some shared resource of quantum entanglement between the players. We say two graphs are quantum isomorphic if there is a winning quantum strategy for the graph isomorphism game. We show that the *-algebraic, C*-algebraic, and quantum commuting (qc) notions of a quantum isomorphism between classical graphs X and Y are all equivalent. This is based on joint work with M. Brannan, A. Chirvasitu, S. Harris, V. Paulsen, X. Su, and M. Wasilewski.

- **Carlynn Fagnant**, Rice University
  Characterizing spatio-temporal trends in extreme precipitation in Southeast Texas

  Rainfall extreme value analysis provides information that has been crucial in characterizing risk, designing successful infrastructure systems, and ultimately protecting people and property from the threat of rainfall-induced flooding. However, in the Houston region recent events (such as the unprecedented rainfall wrought by Hurricane Harvey) have highlighted the inability of existing analyses to accurately characterize current climate conditions. Specifically, there has been little research investigating how spatial patterns of extreme precipitation have shifted through time in the Texas Gulf Coast region, which has led to mis-characterization of existing IDF curves. This study investigates spatio-temporal trends in extreme precipitation in southeast Texas using a statistical approach for peak-over-threshold modeling that employs a generalized Pareto distribution. Precipitation data from over 600 rain gauges across the region are analyzed in 40-year time windows to evaluate shifts in distribution parameters and extreme rainfall levels through time. Spatial analysis of these trends focuses on highlighting regions with increasing, stationary, and decreasing extreme rainfall through time. Results demonstrate heterogeneity in spatio-temporal trends across the entire study region, but significant increases in extreme rainfall over the Houston urban area. Spatial analysis of these trends focuses on how extreme rainfall has changed within different watersheds. Return level estimates of extreme rainfall values are also compared to the current standards for Harris County. Results from this study identify areas that have experienced significant shifts in extreme rainfall, and can help inform where design standards may be inaccurate or outdated.

- **Samreen Khan**, University of Texas at Dallas
  Polar decomposition in certain Lie groups

  Constructive algorithms, not even requiring 2x2 eigencalculations, are provided for finding the entries of the positive definite factor in the polar decomposition of matrices in many groups. These groups include the indefinite orthogonal groups of signature $(1; n-1)$ and $(n-1; 1)$ and fifteen groups preserving certain bilinear forms in dimension four. The Lorentz group belongs to both classes. A key ingredient is a characterization of positive definite matrices in these groups. Two algorithms are proposed for the Lorentz group. The former also works for the group whose signature is $(n-1; 1)$ and $(1; n-1)$. The second enables (and is aided by) the inversion of the double covering of the Lorentz group by $\mathrm{SL}(2; \mathbb{C})$. A key observation is that the inversion of the covering map, when the target is a positive definite matrix, can be achieved essentially by inspection as we demonstrate. We give a simple proof of the fact that positive definite matrices in each of these groups belong to the connected component of the identity, and an explicit expression for their logarithm, and provide a characterization of the symmetric matrices in the connected component of the identity of two of these groups in terms of their preimages in the corresponding covering group.

- **Yan Li**, Baylor University
  A sliding method for the magnetic fractional Laplacian

  We will present a sliding method for the fractional Laplacian. To illustrate how this method can be employed to obtain monotonicity of solutions, we look at semi-linear equations involving the magnetic fractional Laplacian in both bounded domains.

- **Jingbo Liu**, Texas A&M University-San Antonio
  Representations of quadratic forms by sums of squares

  For each positive integer n, let $g_{\mathbb{Z}}(n)$ be the smallest integer such that if an integral quadratic form in n variables can be written as a sum of squares of integral linear forms, then it can be written as a sum of $g_{\mathbb{Z}}(n)$ squares of integral linear forms. We show that as n goes to infinity, the growth of $g_{\mathbb{Z}}(n)$ is at most an exponential function of $\sqrt{n}$. Our result improves the best known upper bound on $g_{\mathbb{Z}}(n)$ which is in the order of an exponential of n.

- **Jane Long**, Stephen F. Austin State University
  Valuations of Sequences Generated by Polynomials

  Sequences of integers can be generated in many different ways, one of which is by evaluating a polynomial with non-negative integer coefficients at the natural numbers $1, 2, 3, \ldots$. Interesting questions arise when we consider the prime decompositions of those outputs:

is a particular prime p ever a factor? Always a factor? Is there a maximum power of p that divides an output? What impact do the characteristics of the polynomial have? These questions can all be framed in terms of the p-adic valuation of a natural number n, denoted $v_p(n)$, which is defined to be the exponent of the highest power of p that divides n. We will examine some surprisingly varied behavior that occurs for even simple (and similar) polynomial functions.

- **Thilini Vasana Mahanama**, Texas Tech University
  A Severe Weather Index Based on the Historic National Oceanic and Atmospheric Administration (NOAA) Data

  Severe weather phenomena, such as tornadoes, floods, and wildfire pose risks to life and property, requires the intervention of authorities. One of the most visible consequences of changing climate is an increase in the intensity and frequency of extreme weather events. The relative strengths of the disasters grow far beyond the habitual seasonal maxima, often resulting in the subsequent increase in property losses. Thus, insurance policies should be modified to sustain regular catastrophic weather events. Our research work proposes a severe weather index for the total loss from natural disasters in the United States and studies how the insurance policies should be adapted to the increasingly volatile climate conditions. National Oceanic and Atmospheric Administration severe weather database is used for this study. It consists of millions of data for 55 types of severe weather events for every state within the United States from 1950 to 2018.

- **Samiha C Rouf**, University of Texas Dallas
  Global dynamics of SIR model with switched transmission rate

  We propose a new epidemiological model, based on the classical SIR model, taking additionally into account a switching prevention strategy. The model has two distinct thresholds that determine the beginning and the end of an intervention and two different transmission rates. We study the global dynamics of the proposed two-dimensional model.

- **Patricia Alonso Ruiz**, Texas A&M University
  The perimeter inside a fractal sponge: formulating the isoperimetric problem in fractals

  The Greek poet Virgil tells in his Aeneid the story of Dido, who bargained to buy from a local king as much land as she could enclose with the hide of an ox. She was able to optimize her purchase by cutting the hide into strips and outlining the shape with the greatest possible area. A way to formulate this problem in mathematical terms would be to find among all shapes with the same perimeter, the one with the greatest area. This is classically called an isoperimetric problem in two dimensions. Already the greeks figured out the solution, namely the circle. In three dimensions, the isoperimetric problem consists in finding among all sets with the same surface area the one that maximizes the volume. Here the sphere is known to solve the problem. But what if our ambient space is something like a sponge full of tiny holes, a fractal? To formulate the isoperimetric problem we need a good notion of perimeter. So, how can we measure the perimeter of a piece of sponge? In this talk we will outline a way to define this notion of perimeter based on how heat propagates in such fractal sets.

- **Hongwei Wang**, Texas A&M International University
  The effect of NSF S-STEM CASC-AID SCHOLARSHIP PROGRAM *on college students*

  Each academic year, NSF S-STEM (SCIENCE, TECHNOLOGY, ENGINEERING AND MATHEMATICS) Program TAMIU College of Arts & Sciences Community-aid (CASC-aid) Scholarship supports 18 STEM scholarships of up to $6,800 based on financial need and academic potential. Students must meet eligibility requirements, including demonstrated financial need to improve recruitment, retention, and graduation rates. By the end of every semester, scholars are required to complete the program participant survey, self-evaluation survey, and success workshops survey. Based on the results of 3 surveys and the GPA from the registration department, researchers want to identity the effect of CACS-aid Scholarship Program in students academic studies as well as mental health. We expect that it provides tools required for employments in the 21st century, balancing professional and family life, and/or applying for and succeeding in graduate and professional schools. Professional development activities will expose students to innovative career opportunities in STEM fields while encouraging students to develop a network of colleagues in the scientific community.

- **Xiaonan (Nikki) Xu**, Lamar University
  p-adic Thickness of Generalized Cantor Set

  A generalized Cantor set is any set C of real numbers of the form $C = I \setminus \bigcup_{i\geq 1} O_i$. Such a set can always be represented as a tree inductively. Based on such representation, a nonnegative quantity called *thickness* can be defined as a measure of how large a Cantor set is. We modify this definition into a p-adic type and explore the consequences. We show that the classic Cantor middle-third set has 3-adic thickness of 1, and that any symmetric construction has p-adic thickness of 1. Furthermore, we construct a generalized Cantor set with a 5-adic thickness less than 1.