WiMSoCal Symposium

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Titles and Abstracts

Keynote Address by

LILY KHADJAVI

LOYOLA MARYMOUNT UNIVERSITY

The ABC Conjecture and Elliptic Curves

The ABC Conjecture has been labeled by some as a "holy grail" of number theory. In 2012, there was exciting news of a possible proof by Shin Mochizuki in number theory circles—and even in the New York Times!—but the tools of his work were so new that years later they are still being verified. To better understand number theorists' interest, we will discuss what the ABC Conjecture is, along with its surprising number of implications. We'll then consider some tools that have been used to tackle it computationally, such as the group structure on elliptic curves, and look at an approach to generating examples of interest for this conjecture.

ABOUT THE SPEAKER:

Dr. Lily Khadjavi is an Associate Professor of Mathematics at Loyola Marymount University in Los Angeles. She earned her bachelors degree from Harvard University and her PhD in Mathematics from the University of California, Berkeley, and she has been a Visiting Scholar at the University of Queensland, in Brisbane, Australia; U.C. Berkeley; and the John Jay College of Criminal Justices Research and Evaluation Center in New York. She serves as a co-chair organizing the Infinite Possibilities Conference (IPC), which builds community for women of color in the mathematical sciences, and the National Science Foundation has funded her work to support retention of underrepresented groups in mathematics, both for the Association of Women in Mathematics and for IPC. Dr. Khadjavi serves on the boards of Building Diversity in Science and the Harvard Gender and Sexuality Caucus.

Weaam Alhejaili, IMS, Claremont Graduate Univ.
A Numerical Study of Steklov Eigenvalue Problem

In this research, we focus on the development of numerical approaches to the forward solver and the shape optimization solver for Steklov eigenvalue problems in two dimensions. This problem has wide range of applications in engineering and applied mathematics. We proposed numerical approaches via spectral methods or finite element methods. To apply spectral methods, we reformulate the Steklov eigenvalue problem in the complex domain via conformal mappings. For shape optimization problem, we use the gradient ascent approach to find the optimal domain which maximizes the k Steklov eigenvalue with a given k.

Nasima Bhuiyan, IMS, Claremont Graduate Univ.
Left Turn Saturation Flow Rate Model Using Regression Model at Signalized Intersections

This research aims to develop a saturation flow rate model exploiting method simple non-linear regression analysis which depends on some independent variables such as start-up lost time, number of opposing lanes, average time headway, average speed and left turning green time. Statistical data analysis is performed to develop micro traffic mathematical model. The ultimate focus of this research is on generating most efficient left turning movement at different levels of congestion (light and heavy left turn traffic). The developed model can be applied in the mitigation of congestion by maximizing flow of traffic.

Cindy Blois, USC
Developing Metaphors Through Open-Ended Art Projects

When you think about a given theorem, such as the Bolzano-Weierstrass Theorem, what images or metaphors does your brain evoke? According to cognitive science (Lakoff and Nuñez, 2000), our understanding and practice of mathematics is underpinned by our conceptual metaphors for abstract mathematical ideas. In this talk, we'll discuss the use of open-ended art projects as a means for allowing students to develop and share their own conceptual metaphors in the classroom, drawing upon examples from undergraduate mathematics courses.

Gulhan Bourget, CSU, Fullerton
Transmission Disequilibrium Test

The Transmission Disequilibrium Test (TDT) compares frequencies of transmission of two alleles from heterozygote parents to an affected offspring. This test requires all genotypes to be known from parents and an offspring. However, obtaining all genotypes in a study might not be possible in some cases. The techniques of imputing only missing parental genotypes or ignoring missing parental genotypes but considering unaffected and affected genotypes have been proposed. We propose a new method called Mendelian Inheritance TDT (MITDT-ONE) that controls type I

error well, and uses Mendelian Inheritance property, and takes population frequency of disease allele and marker allele into account.

Tamara Gomez, UC Santa Barbara
Knotty Outcomes in Billiard Boards of Hexagonal Tiles

Square mosaic knots have many applications in algebra, such as modeling quantum states. We continue the work of the previous REU cohort in extending mosaic knot theory to a theory of hexagonal mosaic knots, which are knots and links embedded in a plane tiling of regular hexagons. We define a new knot invariant, the corona number, by restricting the placement of tiles. We establish the corona number for knots of nine or fewer crossings, excluding 9_16. We also examine tile patches with a high number of link crossings, which we describe as saturated link diagrams. Considering patches of varying size and shape, we identify the number of components and what knots are produced in these saturated link diagrams, with a particular focus on patches circumscribed by regular and irregular hexagons. We also examine how the class of $(2, q)$ torus knots can be constructed on a hexagonal mosaic board, and produce an upper limit on the corona number of these knots. Finally, we discuss open questions relating to the saturated link diagrams and bounds on the corona number for torus knots.

Jennifer Havens, Harvey Mudd College
Application of t-SNE to Biological Data

High dimensional genomic and transcriptomic data is becoming more widely available as sequencing costs go down. The issue which is become more common for scientists is how to interpret such large data sets. t-distributed stochastic neighbor enjoining (t-SNE) is a dimensionality reduction technique that can be applied to wide range of data types including this biological data.

Myra Interiano, UC Irvine
Musical Trends and Predictability of Success in Contemporary Songs On and Off the Top Charts

We analyze more than 500,000 songs released in the UK between 1985 and 2015 to understand the dynamics of success (defined as "making it" into the top charts), correlate success with acoustic features, and explore the predictability of success. Several multidecadal trends have been uncovered. For example, there is a clear downward trend in "happiness" and "brightness", as well as a slight upward trend in "sadness". Furthermore, songs are becoming less "male". Interestingly, successful songs exhibit their own distinct dynamics. In particular, they tend to be "happier", more "party-like", less "relaxed", and more "female" than most. The difference between successful and average songs is not straightforward. In the context of some features, successful songs preempt the dynamics of all songs, and in others they tend to reflect the past. We used random forests to predict the success of songs first based on their acoustic features and then adding the "superstar" variable (informing us whether the song's

artist had appeared in the top charts in the near past). This allowed quantification of the contribution of purely musical characteristics in the songs' success and suggested the time-scale of fashion dynamics in popular music.

Hyun-Jung Kim, USC
Time-Homogeneous Parabolic Anderson Model in One Space Dimension: Existence and Regularity of Solution

Consider the following stochastic parabolic Anderson model with a multiplicative potential

$$ut(t,x) = uxx(t,x) + u(t,x)W(x), u(0,x) = f(x),$$

where $W(x)$ is time-homogeneous Gaussian white noise. Since the white noise is a generalized function, to make sense out of the multiplication $u \ W$, we define several types of solution and find a relation among the solutions. The main project is to prove the optimal regularity of each solution for the equation. We show each solution has the same regularity with the one of the additive model

$$ut(t,x) = uxx(t,x) + W(x), u(0,x) = f(x).$$

Stephanie Lewkiewicz, UCLA
An ODE Model of the Human T-Cell Pool During Thymic Atrophy

The human body hosts a vast pool of T-cells, a crucial component of the adaptive immune system. The thymus provides a constant supply of new T-cells to the peripheral blood, but experiences acute atrophy during physiological stress, for example during infection, starvation, or psychological distress. Atrophy is accompanied by a dramatic decrease in T-cell production, from which the thymus typically recovers after removal of the stressor. We present an ODE model quantifying the effect of this atrophy and subsequent recovery on the size of the peripheral T-cell pool. We derive analytic approximations to the eigenvalues and eigenvectors of the system linearized around equilibria representing the thymus's diseased and healthy states, thereby obtaining estimates of the rates at which the T-cell pool is eradicated during thymic atrophy and regenerated after recovery. We explore the relationship between the time scales of eradication and regeneration in different parameter regimes.

Eilidh McKemmie, USC
Invariable Generation of Finite Classical Groups

There is a probabilistic generation result for the symmetric group which gives rise to a nice Monte Carlo algorithm for computing Galois groups of polynomials. We will extend this result to the finite classical groups using an interesting connection between finite classical groups and their Weyl groups.

Ning Ning, UC Santa Barbara
Weakly Interacting Particle Systems on Random Graphs (LLN, CLT, LDP)

We consider weakly interacting diffusions on the Erdös Rényi random graph. The system consists of a large number of nodes in which the state of each node is governed by a diffusion process that is influenced by the neighboring nodes. This diffusion process is set up with linear but unbounded drift function and constant coefficient. We establish the results of law of large number (LLN), central limit theorem (CLT) and large deviation principle (LDP).

Victoria Noquez, Harvey Mudd College
Notions of Minimality in Continuous Logic

Continuous logic is generalized version of first order logic in which statements will take on some value in the interval $[0, 1]$, rather than just being true or false. This framework was developed to better handle theories of metric structures, and we see that it retains many of the model theoretic tools which have been developed in the classical setting. However, we find that some properties of theories, most notably notions of minimality (which are combinatorial restrictions on definable sets), do not behave analogously to the first order case. In this talk we will discuss notions of minimality in the classical setting, and examine their continuous counterparts.

Ami Radunskaya, Pomona College
At the Intersection of Free Speech and Abstract Proof: A Story

In this talk I will tell you the story of a few theorems that provoked a strong negative reaction in our mathematics community. The experience has made me think more carefully about our role as "experts", and about our responsibility as mathematical modelers. As academics, we can generally work on problems of our choosing. How should we choose those problems? What does "free speech" mean in our professional community? Please join me in a brief discussion of these questions.

Melike Sirlanci, USC
Estimating Input to a Random Diffusion Equation Model for an Alcohol Biosensor Problem

Our work is motivated by an alcohol biosensor problem in which the objective is estimating the BrAC/BAC (Breath Alcohol Concentration/Blood Alcohol Concentration) of individuals given their TAC (Transdermal Alcohol Concentration) based on population data that contains simultaneous BrAC/BAC and TAC measurements. With this goal in mind, we firstly construct a mathematical framework in which we estimate the input to a random diffusion equation model given the output based on the population data. There are two main sub-problems to be solved: (1) parameter estimation problem and (2) deconvolution problem. Due to the uncertainty in the system and the desire to do estimation based on the population data, we assume that the parameters in the model are random variables. So, the first step now becomes

the estimation of the distribution of these random parameters. After that, based on the estimated distribution and the output, we deconvolve the input. We then used this mathematical framework for the alcohol biosensor problem where BrAC/BAC (Breath Alcohol Concentration/Blood Alcohol Concentration) is the input and TAC (Transdermal Alcohol Concentration) is the output. We also present numerical results representing how our approach works in practice by using actual clinical and field BrAC/TAC.

Maria van der Walt, Westmont College
A Deep Learning Approach to Diabetic Blood Glucose Prediction

In this talk, we consider the question of developing a deep learning algorithm for predicting a patient's blood glucose levels. More precisely, suppose that, at time $t = t_0$, we are given estimates of a patient's past blood glucose concentrations, say $s(t_{-6}), s(t_{-5}), \ldots, s(t_0)$, where $t_{-6} < \ldots < t_{-1} < t_0$, with $t_{i+1} - t_i = 5$ minutes. Our goal is to use these past measurements to predict the patient's blood glucose concentration 30 minutes in the future, at time $t = t_6$. The highlights of the talk include the design of the algorithm and numerical results that demonstrate how deep learning can outperform shallow networks in this application. This is joint work with Hrushikesh Mhaskar and Sergei Pereverzyev.

Lora Weiss, UC Irvine
Cellular Control Networks and Their Stability Against Mutations

Cellular tissue consists of stem cells and a hierarchy of more differentiated cells. It is constantly in flux, with differentiated cells dying, and stem cells replenishing the removed cells. In order to maintain constant size, cellular processes must be regulated by control networks of intra-cellular signaling. Here we introduce models of control networks and analyze their robustness against cancerous mutations. Beginning with a stable cellular network, we investigate consequences of different types of mutations, and in particular, which mutations cause a stable network to fail. Relevant to the theory of cancer, these network failures may lead to unlimited growth of mutant cell populations. Our analysis reveals that only specific mutations may cause a stable network to fail.

Angela Wu, UCLA
Weak Tangents of the Sierpinski Carpet

Weak tangents are metric generalizations of tangents of manifolds. In this talk, we will introduce the notion of weak tangents, and illustrate this concept by studying the weak tangents of the Sierpinski Carpet.

Xiao (Luciena) Xiao, Califfornia Institute of Technology
Hecke Orbit Conjecture for PEL Type Shimura Varieties

The Hecke Orbit conjecture asserts that every prime-to-p Hecke orbit in the moduli space of principally polarized abelian varieties is Zariski dense in the central leaf containing it. C.-L. Chai proved the conjecture for Siegel modular varieties using the theory of hypersymmetric points. I will give an overview of the background and discuss some partial results of the analogue for PEL type Shimura varieties. This is part of my PhD thesis project under the supervision of Elena Mantovan.

Fanhui Xu, USC
On the Cauchy Problem for Integro-Differential Equations Associated to Alpha-Stable Like processes

The Cauchy problem of a parabolic integro-differential equation is investigated in Holder-Zygmund spaces. The elliptic operator of the equation is associated to an alpha-stable like stochastic process. Existence and uniqueness of the solution is proved by some priori estimates. Regularity results are obtained as well.

Felicia Young Tabing, USC
Mon Mathematics, Aesthetics, and Culture

Japanese heraldry emblems, called *mon*, are in the form of circular arrangements that feature many designs which resemble geometric or mathematical objects. Some of the designs even feature knots, links, and iterations of fractals. Interestingly, a few *mon* designs look very similar to sangaku problems, which are mathematical problems posted on wooden tablets at temples in Japan during the Edo period that feature the problem and solution. The type of mathematical problems in sangaku problems have a very distinct aesthetic in comparison to Western math problems. I will discuss how *mon* ties together mathematics, culture, and aesthetics of Japanese art and mathematics.