

Murmurations in Arithmetic Geometry and Related Topics: November 11-15, 2024

Events for:
Monday, November 11th - Friday, November 15th

Monday, November 11th

8:30am **Workshop: Breakfast - SCGP Cafe**

Title: Breakfast

9:30am **Workshop: Andrew Sutherland - SCGP 102**

Speaker: Andrew Sutherland

Title: Murmurations of arithmetic L-functions

Abstract: I will report on ongoing efforts to understand murmurations in families of arithmetic L-functions, including L-functions of modular forms, elliptic curves and their symmetric powers, and of abelian surfaces

10:30am **Workshop: Coffee Break - SCGP Cafe**

Title: Coffee Break

11:00am **Workshop: Min Lee - SCGP 102**

Speaker: Min Lee

Title: Murmurations of Maass forms

Abstract: In this talk, I will present joint work with Andrew R. Booker, David Lowry-Duda, Andrei Seymour Howell, and Nina Zubrilina, exploring the murmurations of Maass forms. We prove the existence of such murmurations within families of L-functions associated with Maass forms of weight 0 and level 1, as their Laplace eigenvalue parameter tends to infinity.

12:00pm **Workshop: Lunch - SCGP Cafe**

Title: Lunch

1:00pm **Workshop: Steven Miller and Tomothy Cheek - SCGP 102**

Speaker: Steven Miller and Tomothy Cheek

Title: Numerical Investigation of Lower Order Biases in Moment Expansions of One-Parameter Families of Elliptic Curves

Abstract: For a fixed elliptic curve E without complex multiplication, $a_p := p+1 - \#\mathbb{E}(\mathbb{F}_p)$ is $O(\sqrt{p})$ and $a_p/2\sqrt{p}$ converges to a semicircular distribution. Michel proved that for a one-parameter family of elliptic curves $y^2 = x^3 + A(T)x + B(T)$ with $A(T), B(T) \in \mathbb{Z}[T]$ and non-constant j -invariant, the second moment of $a_p(t)$ is $p^2 + O(p^{\{3/2\}})$. The size and sign of the lower order terms have applications to the distribution of the zeros near the central point of the associated L -functions (i.e., the Birch and Swinnerton-Dyer Conjecture). Based on data from special families where the Legendre sum calculations can be done in closed form to compute the second moment, S. J. Miller conjectured that the highest order term of the lower order terms of the second moment that does not average to zero is on average negative; this is now known for many families where $A(T), B(T)$ have small degree, and in many cases interesting arithmetic emerges in these lower order terms. We create a database and a framework to quickly and systematically investigate biases in the second moment of **any** one-parameter family, justifying the large start-up cost needed. When looking at families which have so far been beyond current theory, we find several potential violations of the conjecture for $p \leq 250,000$ and discuss new conjectures motivated by the data, especially for higher moments (which are not theoretically tractable as they involve at least cubic Legendre sums).

2:30pm **Workshop: Nina Zubrilina - SCGP 102**

Speaker: Nina Zubrilina

Title: TBA

Abstract: TBA

3:30pm **Workshop: Tea Time - SCGP Cafe**

Title: Tea Time

4:00pm **Workshop: Kimball Martin - SCGP 102**

Speaker: Kimball Martin

Title: Distributions of local signs and murmurations

Abstract: Murmurations describe a correlation between Fourier coefficients and global root numbers of modular forms. I will describe analogous phenomena for local root numbers, including the degenerate case of no root numbers.

Tuesday, November 12th

8:30am **Workshop: Breakfast - SCGP Cafe**

Title: Breakfast

9:30am **Workshop: Edgar Costa - SCGP 102**

Speaker: Edgar Costa

Title: Computing L-functions

Abstract: We overview several methods to compute the Dirichlet coefficient of L-functions for several families, including Calabi-Yau varieties (curves to 3folds) and hypergeometric motives.

10:30am **Workshop: Coffee Break - SCGP Cafe**

Title: Coffee Break

11:00am **Workshop: Jonathan Bober - SCGP 102**

Speaker: Jonathan Bober

Title: TBA

Abstract: TBA

12:00pm **Workshop: Group Photo - SCGP Lobby**

Title: Group Photo

12:00pm **Workshop: Lunch - SCGP Cafe**

Title: Lunch

1:00pm **Workshop: Matilde Lalin - SCGP 102**

Speaker: Matilde Lalin

Title: Random matrix theory and distributions of multiplicative functions

Abstract: We will discuss some connections between the variance of multiplicative functions (particularly the divisor function) for the function field $\mathbb{F}_q[T]$ and certain integrals over the ensembles of unitary and symplectic matrices. We will report on recent advances on the formulation of conjectures over the number field case for problems connected to symplectic matrices. This is joint work with Vivian Kuperberg.

2:30pm **Workshop: Zeyu (Steven) Wang - SCGP 102**

Speaker: Zeyu (Steven) Wang

Title: Murmurations of Hecke L-functions of imaginary quadratic fields

Abstract: We compute the murmuration density for the family of Hecke L-functions associated to non-trivial Hecke characters on the class group of imaginary quadratic fields with 1-mod-4 discriminant. One interesting phenomenon about this family is that after averaging the Frobenius traces $a_p(f)$ over the family, the murmuration density has a mild dependence on the arithmetics of p , and a second average over primes is required. We also analyze the asymptotic behavior of the murmuration.

3:30pm **Workshop: Tea Time - SCGP Cafe**

Title: Tea Time

4:00pm **Workshop: Ursula Whitcher - SCGP 102**

Speaker: Ursula Whitcher

Title: Explicit point counting for Delsarte K3 quartic surface pencils

Abstract: We study ten pencils of Delsarte K3 quartic surface pencils that arise naturally in the context of mirror symmetry. We use finite field hypergeometric equations and hypergeometric Picard-Fuchs differential equations to describe their point counts over finite fields, together with associated L-functions and modular forms, and explore the implications for related families of Calabi-Yau threefolds.

Wednesday, November 13th

8:30am **Workshop: Breakfast - SCGP Cafe**

Title: Breakfast

9:30am **Workshop: Kumar Murty - SCGP 102**

Speaker: Kumar Murty

Title: TBA

Abstract: TBA

10:30am **Workshop: Coffee Break - SCGP Cafe**

Title: Coffee Break

11:00am **Workshop: David Lowry-Duda - SCGP 102**

Speaker: David Lowry-Duda

Title: TBA

Abstract: TBA

12:00pm **Workshop: Lunch - SCGP Cafe**

Title: Lunch

1:00pm **Workshop: Matija Kazalicki - SCGP 102**

Speaker: Matija Kazalicki

Title: Improving Mestre-Nagao heuristics with data science

Abstract: The Mestre-Nagao sums, based on the Birch and Swinnerton-Dyer conjecture, offer heuristics for identifying elliptic curves of high rank. In this talk, we present data science experiments—some drawing inspiration from murmurations of elliptic curves—aimed at improving the performance of these sums and developing new heuristics. Our focus is on both classifying high-rank curves and distinguishing between curves of rank 0 and 1. This is a joint work with Zvonimir Bujanovi?, Lukas Novak, and Domagoj Vlah.

2:30pm **Workshop: TBA - SCGP 102**

Speaker: TBA

Title: TBA

Abstract: TBA

3:30pm **Workshop: Tea Time - SCGP Cafe**

Title: Tea Time

4:00pm **Workshop: Raimundas Vidunas - SCGP 102**

Speaker: Raimundas Vidunas

Title: Conway's "Life" perturbed

Abstract: This recreational talk will concern John Conway's famous game "Life", which is by far the best known cellular automaton. Its simple rules generate often unforeseeably complicated evolution of live and dead cells in a rectangular lattice. We will consider a perturbed variant of "Life" where errors (of following the rules) are possible with a small probability. The error probability at each step is assumed to be so small that the errors would only affect stabilized patterns, including cyclical or moving patterns. This gives a Markovian process between the stabilized patterns. Such a stochastic model should approximate emergence of complexity and live processes more interestingly than Conway's original game. Concrete results will be presented for this new game on small toruses, of size up to 10x10 cells.

6:00pm **Workshop: Banquet Dinner - SCGP 102**

Title: Banquet Dinner

Thursday, November 14th

8:30am **Workshop: Breakfast - SCGP Cafe**

Title: Breakfast

9:30am **Workshop: Ariel Pacetti - SCGP 102**

Speaker: Ariel Pacetti

Title: Computing paramodular forms I

Abstract: The goal of this talk is to explain how cohomological degree two Paramodular forms can be computed. We will start recalling the basic definitions and main properties of degree two Siegel modular forms, and explain the relation between paramodular forms and definite orthogonal modular forms on quinary lattices. The later forms are well suited for computations, as will be explained in Tornaria's talk.

10:30am **Workshop: Coffee Break - SCGP Cafe**

Title: Coffee Break

11:00am **Workshop: Gonzalo Tornaria - SCGP 102**

Speaker: Gonzalo Tornaria

Title: Computing paramodular forms II

Abstract: The second part of the talk will be how to compute the quinary forms, and the Hecke operators acting on them (as in the tables he computed with Gustavo Rama).

12:00pm **Workshop: Lunch - SCGP Cafe**

Title: Lunch

1:00pm **Workshop: Alex Cowan - SCGP 102**

Speaker: Alex Cowan

Title: Murmurations and ratios conjectures

Abstract: Subject to GRH, we prove that murmurations arise for primitive quadratic Dirichlet characters, and for holomorphic modular forms of prime level tending to infinity with sign and weight fixed. Moreover, subject to ratios conjectures, we prove that murmurations arise for elliptic curves ordered by height, and for quadratic twists of a fixed elliptic curve. We demonstrate the existence of murmurations for these arithmetic families using results from random matrix theory.

2:30pm **Workshop: Edward Hirst - SCGP 102**

Speaker: Edward Hirst

Title: Machine Learning Cluster Algebras

Abstract: Cluster Algebras have shown recent popularity due to their various applications within physics. They are defined via mutation process acting on a seed of generators, where physically this mutation connects equivalent gauge theories under Seiberg duality. The mutation process leads to rich combinatorics, here studied through the lens of machine learning, where classification methods learn to distinguish algebras, and network science methods promote the raising of new conjectures. For applicability of many cluster algebra theorems one is interested in an algebras mutation-acyclicity, a property we examine with machine learning and use interpretable methods to hint at the structure of new relevant mutation invariants.

3:30pm **Workshop: Tea Time - SCGP Cafe**

Title: Tea Time

Friday, November 15th

8:30am **Workshop: Breakfast - SCGP Cafe**

Title: Breakfast

9:30am **Workshop: Nutsa Gegelia - SCGP 102**

Speaker: Nutsa Gegelia

Title: Paramodular forms from Calabi-Yau operators

Abstract: We report on the conjectural identification of paramodular forms from Calabi-Yau motives of Hodge type $(1,1,1,1)$ of moderately low conductor. The identifications are done by calculating Euler factors from Calabi-Yau operators from the AESZ list, seeking a match with Hecke eigenvalues provided in the paramodular forms database and checking the approximate functional equation for the Euler product numerically.

10:30am **Workshop: Coffee Break - SCGP Cafe**

Title: Coffee Break

11:00am **Workshop: Alexey Pozdnyakov - SCGP 102**

Speaker: Alexey Pozdnyakov

Title: Murmurations of quadratic characters

Abstract: We calculate murmuration densities for several families of Dirichlet L-functions, focusing on the case of L-functions arising from quadratic characters. We also prove that the resulting murmuration function interpolates the phase transition in the 1-level density for a symplectic family of L-functions.

12:00pm **Workshop: Lunch - SCGP Cafe**

Title: Lunch

3:30pm **Workshop: Tea Time - SCGP Cafe**

Title: Tea Time