Student Research Session
Session de présentations de recherche par les étudiants

SHOHEL AHMED, University of Alberta
Modelling Foraging Behavior in Ecological Dynamics

Foraging behavior is often highly flexible, with individuals adjusting how, when, and where they feed in response to changing environmental conditions and predation risk. In this work, a set of mechanistic models is developed to investigate how such foraging flexibility shapes population dynamics and ecosystem functioning. First, consumer–resource models are formulated in which attack rates adapt to food availability and population density, capturing behavioral feedback between foraging effort and resource depletion. Second, nutrient balance and food quality are incorporated into stoichiometric foraging models that link diet choice to growth efficiency and energy allocation. Together, these complementary frameworks demonstrate how flexible foraging decisions, grounded in explicit mechanistic processes, can stabilize or destabilize ecological dynamics and generate diverse outcomes in community structure and resilience.

ADRIAN CHITAN, Western University
Stratification of the half-density quantization of the Jeffrey-Weitsman-Witten invariants

This talk presents a stratified quantization procedure motivated by the geometric foundations of the Jeffrey-Weitsman formalization of Witten's 3-manifold invariants. The core challenge we address is the singular structure of the space of flat connections on the bounding surface that extend into the handlebody—the so-called Lagrangian leaf, and the natural quantization procedure it suggests.

AMAURY DE BURGOS, University of Calgary
On the length of cyclic algebras

Cyclic algebras were first introduced by Leonard Eugene Dickson in 1906. He remarked that, for appropriate choice of parameters, his construction yielded a division algebra. These cyclic division algebras were one of the earliest examples of non-commutative division algebras over a field and are now applied in wireless communication systems (e.g. 4G LTE, 5G, Wi-Fi networks) via space-time block coding.

A notable numerical invariant of any algebra over a field is its length, defined as the length of its longest chain of linear subspaces. In 2016, the length of 4-dimensional cyclic algebras was proven to be 2. Five years later, the length of cyclic algebras of dimension 9, 16, and 25 was stated to be 4, 6, and 8 respectively. We show these latter values are ill-derived, meaning the length of cyclic algebras of dimension greater than 4 is still an open problem.

In pursuit of solving this open problem, we construct an infinite family of cyclic division algebras and give a lower bound on the length of its members. Lastly, we tensor members of a subfamily with the Gaussian rationals to produce fully-diverse linear space-time block codes with non-vanishing determinant.

SHAN GAO, University of Alberta
Tipping in Ecological Systems Driven by Periodic Climate Variability

Tipping points refer to abrupt, substantial, and often irreversible transitions in dynamic systems that can be triggered by minor perturbations. Four tipping mechanisms are recognized: bifurcation-induced tipping (B-tipping) focusing on the magnitude of changes, rate-induced tipping (R-tipping) focusing on the rate of changes, noise-induced tipping (N-tipping) emphasizing the role of randomness or noise, and phase-induced tipping (P-tipping) highlighting the timing or phase of changes. In this talk, I will introduce another plausible way to trigger sudden shifts: a deterministic system can be driven to a tipping point by periodic external forcing inputs whose amplitude never crosses the critical threshold.

THANH HUYNH, McMaster University
A numerical approach for local isoperimetric partitions

We propose and study a numerical algorithm for isoperimetric partitioning problems with volume constraints. The algorithm is based on a total variation formulation to measure the perimeters of the sets, and an ADMM relaxation and FFT is used to formulate and solve the associated optimality conditions. We validate our method against known examples like the half space and sphere, before examining numerically the convergence properties. Finally, we propose several conjectures about minimizing configurations.

RICK LU AND HAONAN ZHAO, University of Toronto
L-functions and Numerical Computations Concerning Landau-Siegel Zeros

Let χ be a Dirichlet character mod q, $L(s,\chi) = \sum_{n=1}^{\infty} \frac{\chi(n)}{n^s}$ be the associated Dirichlet L-function, and $s = \sigma + it$ be a complex number. (If $\chi \equiv 1$ then L is the Riemann zeta function.) Let $\zeta_q(s) = \prod_{\chi} L(s,\chi)$ where χ ranges over all Dirichlet characters of modulus q. A theorem due to Landau showed that there is a constant $c > 0$ such that for all q, $\zeta_q(s)$ has at most one zero in the region

$$\sigma \geq 1 - \frac{c}{\log\left(q(|t|+1)\right)}, \tag{1}$$

and furthermore if there is such a zero, then it is necessarily real and the associated character χ is quadratic. Such a zero, if it exists, is called a Landau-Siegel zero or an exceptional zero. It is a particular kind of counterexample to the Generalized Riemann Hypothesis. Proving the nonexistence of Landau-Siegel zeros is of great interest, with applications to e.g. bounds on class numbers of quadratic number fields.

In this talk, we will demonstrate a new computational result regarding the non-existence of such zeros. Following methods that were developed by Heath-Brown, and Thorner and Zaman, we refined an inequality concerning the logarithmic derivative of Dirichlet L-functions and their largest real zeros. With modern computing clusters, we utilized this inequality and computationally verified that Landau-Siegel zeros do not exist for any quadratic character of modulus $q \leq 10^{10}$, with $c = 1/5$ in the above region.

DARICHE NGUYEN, McMaster University
Weak anchoring around a colloidal particle

In the mathematics of liquid crystals, we study minimizers of the Landau-de Gennes energy in $\mathbb{R}^3 \setminus B_1(0)$ with external magnetic field in the large particle limit. We impose weak surface anchoring on the boundary and derive a lower bound for the energy in terms of the optimal boundary condition. We also conjecture about what these optimal boundary conditions look like for a few different cases of weak anchoring.

AUSTIN SUN, University of Toronto
The Grassmannian of lines as the space of pencils of binary quantics: towards a GIT-free PGL_2-stratification of $Gr(2, n+1)$

In the last century, geometric invariant theory (GIT) has been central to the study of reductive group actions on varieties such as Grassmannians. Using GIT, one may classify orbits of a reductive group acting on an algebraic variety and obtain stratifications of that variety consisting of collections of orbits. However, even with well-studied examples such as the n-dimensional projective space viewed as the space of binary quantics under the natural PGL_2-action, we only know explicit stratifications for small n's: as n grows larger, one would have to compute exceptionally large numbers of polynomial invariants for the PGL_2-action in order to give an explicit stratification.

The goal of this talk is to illustrate an approach for constructing PGL_2-stratifications of the Grassmannian $Gr(2, n+1)$ viewed as the space of pencils of binary quantics with minimal knowledge of GIT, which is the subject of one of the speaker's current research directions. Specifically, the proposed approach will not involve any computations of polynomial invariants for the PGL_2-action, and will be based on the Hilbert-Mumford criterion, Schubert cell decompositions as well as the theory of algebraic groups. I will discuss some of the unresolved difficulties for writing down explicit PGL_2-stratifications for $Gr(2, n+1)$ in general, and make connections to contemporary research on PGL_2-stratifications for the projective space as the space of binary quantics.

JIATONG SUN, University of Alberta
Data-Driven Computation for Periodic Stochastic Differential Equations

Many stochastic differential equations in various applications, like coupled neuronal oscillators, are driven by time-periodic forces. In this talk, I will introduce several data-driven computational tools extended from the autonomous Fokker-Planck equation to the time-periodic setting. This enables the efficient computation of the time-periodic invariant probability measure using either a grid-based method or an artificial neural network solver, and the estimation of the speed of convergence towards the time-periodic invariant probability measure. I will also show the convergence analysis and performance of the algorithms using several numerical examples.

KATE TRETIAKOVA, University of Ottawa
"But How Do We Know?": Epistemological Trespass in the Math Classroom

What do mathematicians, TAs, and students assume it means to know something in mathematics, and why does it matter?

This talk introduces core epistemological perspectives that quietly shape mathematical teaching: correspondence, coherence, pragmatism, constructivism, and more. Rather than debating the truth, epistemological pluralism invites us to notice how different lenses highlight different aspects of the same classroom moment.

Through examples from undergraduate courses, I'll illustrate how instructors' implicit epistemologies influence what they emphasize and how these choices shape students' experiences. We then examine the promise and frustration of constructivist teaching: why mathematics education advocates for it, and why students who have grown up with high expectations of mathematical authority often encounter difficulties.

The session offers practical insights for TAs and future instructors seeking to design learning environments that align with both mathematical values and real students, while giving experienced educators room for re-interpreting familiar challenges and seeing their practice in a new light.