APIC 24 SUMMER SCHOOL ABSTRACTS

Courses:

- Amin Coja-Oghlan
  Technical University of Dortmund, Germany
  The statistical mechanics of random combinatorial structures: The goal of statistical mechanics is to explain macroscopic behaviour from the microscopic interactions of myriads of small particles. One particularly challenging sub-discipline of statistical mechanics deals with disordered systems, where the microscopic interactions themselves result from a random experiment. Recently a close connection between such disordered systems and problems in combinatorics, statistics and computer science has emerged. The aim of this lecture is to give a brief overview of some of these ideas and of the most important mathematical techniques.

- Venkatesan Guruswami
  University of California, Berkeley, USA
  Error-correcting codes and algorithms: Error-correcting codes play an important role in many areas of science and engineering, as they safeguard the integrity of data against the adverse effects of noise in communication and storage. They have also become important tools in computer science and discrete mathematics. Starting from the basics of coding theory and some of the classic theorems (and challenges) of the subject, the course will cover some central code constructions and error-correction algorithms. Along the way, we will attempt to provide a glimpse of the richness of the subject in terms of the different noise and decoding models, and varied mathematical techniques used to design error-correction schemes.

- Ryan O'Donnell
  Carnegie Mellon University, Pittsburgh, US
  The Theory of Computation: Just as Theoretical Physics is the mathematical modeling and study of physical processes in our universe, Theoretical Computer Science is the mathematical study of all the *computational* processes in our universe. In this course we will describe the mathematical foundations of computing, starting from the mathematical formalization of computation and algorithms, and reaching to diverse topics such as Gödel's Incompleteness Theorem, the "P vs NP problem", theoretical cryptography, and quantum computation.

Research talks:

- **Rinel Foguen**

Title: Linear quadratic graphon field games.

Abstract: We study finite games with a large number of players weakly coupled over a network structured as a weighted undirected dense graph. The graph influences both the players' linear dynamic states and their quadratic objective functions. We consider a sequence of such finite games as the number of players goes to infinity and the graph converges to a graphon. The limit games are called linear quadratic graphon field games. Under finite rank assumptions on the graphon, we can show existence of an equilibrium for these linear quadratic graphon field games and justify the limit via the derivation of approximate Nash equilibria for the finite games. This is joint work with Shuang Gao and Peter Caines.

- **Yvonne Kariuki**

COUNTING FORMULAS AND BIJECTIONS OF NON-DECREASING 2-NONCROSSING TREES

Abstract
In the past quarter-century, noncrossing trees have received considerable attention as counting objects and have been generalized by assigning labels to the vertices and considering block graphs. Noncrossing trees are defined as trees whose vertices lie on the circumference of a circle and whose edges do not intersect inside the circle. This talk introduces non-decreasing 2-noncrossing trees and enumerates them according to their number of vertices, root degree, and number of forests. It also introduces non-decreasing 2-noncrossing increasing trees and counts them by considering their number of vertices, label of the root, label of the leftmost child of the root, root degree, and forests. It is observed that the formulas enumerating the newly introduced trees are generalizations of little and large Schröder numbers. Furthermore, bijections between the sets of non-decreasing 2-noncrossing trees, locally oriented noncrossing trees, labelled complete ternary trees, and 3-Schr¨oder paths are introduced.

- **Olivia Nabawanda**

Title: A weighted Murnaghan–Nakayama rule for (P, w)-partitions

Abstract: The (P, w)-partition generating function K(P,w)(x) is a quasisymmetric function obtained from a labeled poset. Recently, Liu and Weselcouch gave a formula for the coefficients of K(P,w)(x) when expanded in the quasisymmetric powersum function basis. This formula generalizes the classical Murnaghan–Nakayama rule for Schur functions.

We extend this result to weighted (P, w)-partitions, and give a short combinatorial proof. Our approach involves defining an appropriate probability space, characterized by integer vectors that can be represented through staircase diagrams.

This is joint work with Per Alexandersson (Stockholm University–Sweden).

- **Franck Kamwa**

Title: Low-Rank Parity-Check (LRPC) codes over finite commutative rings.

Abstract :
Recent works have shown that rank metric codes over rings could be a promising direction for cryptography as some attacks may not work due to the existence of zero divisors for example. LRPC codes are considered as a less structured alternative to Gabidulin codes and the rank metric equivalent of LDPC codes in Hamming metric. In this work, we show how to extend the definition of LRPC codes from finite fields to finite commutative rings.

- **Frank Namugera**

Title: *The contact process on long-range networks.*

Abstract: *We investigate the interplay between the long-range networks and the contact process parameters. In particular, we show that* the contact process dies out at criticality for a given power law exponent α and dimension d*. Furthermore, in the super-critical regime, the truncated process survives. Our proofs use a block argument to draw comparisons with percolation theory.*

- **Naina Ralaivaosaona**

Title: Galton-Watson Trees and Their Parameters
Abstract: Galton-Watson trees are probabilistic models of random trees. They have been studied extensively in the literature. These models are determined by an offspring distribution, which is an integer-valued random variable. When conditioned to have a fixed number of nodes, Galton-Watson trees model many uniform combinatorial random trees, such as rooted labelled trees, plane trees, and binary trees. In this talk, I will discuss the conditioned Galton-Watson model and its relationship with many combinatorial tree models, providing explicit examples. Furthermore, I will discuss the limiting distributions of various natural parameters of these random tree models.