Stanford Math Directed Reading Program Colloquium

Spring 2017, Session 2

Thursday, June 8, 2017, 6:30pm–8:30pm
Sloan Mathematics Center, rooms 384-H and 384-I (fourth floor)
Dinner available on fourth floor at 6:15pm

Session A, room 384-H

Cyclotomic theory of prime distribution

6:30pm

Chenlin Meng
Mentor: Alessandro Maria Masullo

We will give an overview of Dirichlet's theorem on arithmetic progressions within primes, with proof in a special case. We will indicate certain analytic phenomena concerning prime distribution, and state how these results are generalized and explained by the theory of zeta functions, as will be spelled out in a further short talk in the fall.

Properties and applications of holomorphic functions

6:50pm

Joshua Kazdan
Mentor: Michail Savvas

After introducing the definition of a holomorphic function over the complex plane, I will explain the Cauchy-Riemann equations. Using these tools, I will supply a proof of the fundamental theorem of algebra using methods from complex analysis. A discussion of singularities and the complex logarithm will follow. Finally, I will suggest methods of integrating challenging functions using Morera's theorem.

Reaching agreement

7:10pm

Andy Chen
Mentor: Alex Zhai

Suppose Alice and Bob are discussing whether Eve will be the next president of the United States. If they keep exchanging information, will they ever mostly agree? It turns out that if both people are strictly rational, with high probability, the answer is yes! To show this, we first describe the situation more precisely by representing Alice and Bob's beliefs as partitions over a space of possible "worlds", one of which is the "correct" world. We then discuss how exchanging information refines those partitions, ultimately causing Alice and Bob to reach similar views.

Arithmetic progressions in dense sets

7:30pm

Madelyne Xiao
Mentor: Yuval Wigderson

What structure can we find in (apparent) chaos? This is a generalization of the goals of Ramsey theory, which we apply here to investigate arithmetic progressions in dense sets of the positive integers. That is, given a set of integers such that individual elements of the set aren't too "spaced out," can we find arithmetic progressions of the form $a, a+d, a+2d$ ...? Can we bound the size of the set of integers required to find an arithmetic progression of a certain length?

In my talk, I'll go over a nifty proof of van der Waerden's theorem, an early result in this area, and briefly discuss some more recent results as time allows, including Szemerédi's theorem, the Green-Tao theorem, and the Erdős-Turán conjecture.

Cohomology of differentiable manifolds

7:50pm

Nik Castro
Mentor: Shotaro Makisumi

Algebraic topology concerns itself with distinguishing topological spaces from one another by assigning to them various algebraic invariants. One of the most commonly used for general topological spaces is called "singular cohomology," while in the setting of differentiable manifolds one can also define "de Rham cohomology." This talk will introduce both, and at the end state the surprising de Rham theorem: that the two theories are isomorphic.

The Learning With Errors problem and an application to cryptography

8:10pm

Katy Woo
Mentor: Jonathan Love

Learning With Errors (LWE) cryptosystems are amongst the most efficient and currently quantum-secure cryptosystems. I will introduce the Search and Decision variants of the LWE Problem and explain their equivalence. Then I will present a public key cryptosystem based off of Decision LWE.

Session B, room 384-I

Cyclic covers of knot complements

6:30pm

Jared Bitz

Mentor: Weston Ungemach

Knot theory derives many of its powerful techniques from examining not knots themselves, but their complements — the space left behind after the knot is removed. For a given knot complement, we will describe and construct special covering spaces called "cyclic covers," which possess many rich algebraic invariants that help us distinguish knots from each other. We will do this through special objects called Siefert surfaces, which lend themselves to many beautiful visualizations.

Hidden Markov models and their applications in speech recognition

6:50pm

Yousef Hindy

Mentor: Sarah McConnell

Accurate and fast speech to text translation is vital for keeping up with recent advances in natural language processing and the development of commercial assistant services like Amazon's Alexa or Apple's Siri. Hidden Markov Models (HMMs) are the basis of how these speech recognition technologies operate. In this presentation, I will first discuss the basic theory of first order discrete Markov processes. Next, I will examine the structure of HMMs and elaborate on the basic problems that are essential to using HMMs in practice. Finally, I give a brief outline of how a one word classifier would work in practice.

Dirichlet's Theorem on primes in arithmetic progression

7:10pm

Milan Mossé

Mentor: Nikolas Kuhn

Dirichlet's 1837 publication of the theorem on primes in arithmetic progression marked the introduction of L-functions, the theory of which has come to occupy a substantial part of the field of arithmetic number theory. This will be a presentation of a proof of the theorem, which states that there are infinitely many primes that are a mod q for any coprime a, q.

An exploration of spectral graph theory

7:30pm

Yonatan Oren
Mentor: Caitlin Stanton

Spectral graph theory aims to relate the structural properties of a graph with the spectrum of its adjacency matrix. In this presentation I will explore the relationship between the connectivity of a graph and the eigenvalues of its adjacency matrix, and introduce the notion of a spectral gap and relate it to mixing time. In addition, I will introduce briefly some topics that make use of this relationship, including expander graphs and their use in theoretical computer science.

Combinatorial species

7:50pm

Zoe Himwich
Mentor: Joj Helfer

A species is a functor which takes a finite set, U, to the set of a given type of structures on U. For example, the species of linear orders is a functor which takes an underlying finite set U to the set of all linear orders on U. Species on sets can be described using several types of generating series. Operations like addition, multiplication, and composition of species are usually presented as operations on the generating series. This talk will explain the concept of a combinatorial species in more detail and then give a few examples of how to use species as a tool to solve problems.

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