Talks in theoretical sciences

Monday, 25 November 2019

ETH-ITS, seminar room, CLV B4

Speaker: Laurent Côté

Time: 09:15 – 9:45

Title: Some applications of complex Floer theory to topology

Abstract: I will describe an approach to defining diffeomorphism invariants of low-dimensional manifolds and knots. Morally, these invariants are based on counting solutions to certain equations coming from quantum field theory. However, their rigorous construction relies on ideas from (complex) symplectic topology and algebraic geometry. Parts of this talk are based on joint work with Ciprian Manolescu and Ikshu Neithalath, as well as work in progress.

Speaker: Christoph Kehle

Time: 10:15 – 10:45

Title: Determinism in General Relativity and its connection to Diophantine Approximation

Abstract: The statement that general relativity is deterministic finds its mathematical formulation in the celebrated 'Strong Cosmic Censorship Conjecture' due to Roger Penrose. I will present my progress on this conjecture in the case of negative cosmological constant and in the context of black holes. It turns out that this is intimately tied to Diophantine properties of a suitable ratio of mass and angular momentum of the black hole.

Speaker: Thibault Lefeuvre

Time: 11:30 – 12:00

Title: The marked length spectrum of negatively-curved manifolds

Abstract: In 1985, Burns and Katok conjectured that the marked length spectrum of a closed negatively-curved manifold (i.e. the collection of lengths of closed geodesics marked by free homotopy) should determine the metric up to isometries. Otal and Croke independently proved the conjecture in 1990 for surfaces and despite some progress achieved in the 90s the problem did not really evolve until our proof of a local version of the conjecture obtained with Guillarmou. More recently, we showed with Knieper and Guillarmou a sharper bound on the way the distance between isometry classes is controlled by the length spectrum and – passing by – generalized some notions initially defined on Teichmüller space to higher dimensions and the setting of variable curvature. I will discuss the results and explain some of the key ingredients in the proofs. I will also indicate some further perspectives of research.

Speaker: Shota Komatsu

Time: 14:15 – 14:45

Title: Tailor-made solution to gauge theory

Abstract: Gauge theory is one of the most basic frameworks in modern physics and describes most notably Quantum Chromodynamics, namely the physics of quarks and gluons. Despite its importance, understanding the dynamics of gauge theories is notoriously difficult since it is strongly interacting at low energy. In 70's, 't Hooft pointed out that, in the limit where the number of colors is infinite, there is a alternative and possibly simpler description of gauge theories which is based on two-dimensional surfaces. Although this led to various interesting discoveries in the past 40 years, the dynamics on two-dimensional surfaces turned out to be difficult to analyze and remained as an important open problem. In my talk, I will describe the recent progress in solving a certain gauge theory in 3+1 dimensions based on my own research. The key idea is to describe a two-dimensional surface by decomposing it into basic building blocks, which geometrically correspond to hexagonal patches. I will also describe surprising connections to statistical mechanics which allowed us to determine these building blocks.

Speaker: Lisa Sauermann

Time: 15:15 – 15:45

Title: On counting algebraically defined graphs

Abstract: For many classes of graphs that arise naturally in discrete geometry (for example intersection graphs of segments or disks in the plane), the edges of these graphs can be defined algebraically using the signs of a finite list of fixed polynomials. We investigate the number of n-vertex graphs in such an algebraically defined class of graphs. Warren's theorem (a variant of a theorem of Milnor and Thom) implies upper bounds for the number of n-vertex graphs in such graph classes, but all the previously known lower bounds were obtained from ad hoc constructions for very specific classes. We prove a general theorem giving a lower bound for this number (under some reasonable assumptions on the fixed list of polynomials), and this lower bound essentially matches the upper bound from Warren's theorem. For the proof of our result we use some tools from algebraic geometry and differential topology.

Speaker: Visu Makam

Time: 16:30 – 17:00

Title: A complexity-theoretic view of invariant theory

Abstract: Abstract: Invariant theory is the study of symmetries in the setting of group actions via invariant polynomials, i.e, polynomials that are unchanged by the group action. This subject has had a deep and lasting influence on many areas of mathematics. Indeed, Lie theory, algebraic geometry, differential algebra, and algebraic combinatorics are all offsprings of invariant theory.

At the turn of the 20th century, foundational results established by giants such as Hilbert and Weyl launched a program that lasted several decades. In the middle of the 20th century,

Mumford's geometric invariant theory program marks another turning point in the subject. In the last two decades, we are witnessing yet another exciting turning point in invariant theory brought about by the influence of complexity theory.

In this talk, I will highlight the connections between invariant theory and foundational problems in complexity theory such as identity testing and P vs NP, briefly discuss the invariant theoretic problems inspired by these connections, and present some recent results from joint works with Harm Derksen, Ankit Garg, Rafael Oliveira, and Avi Wigderson.