2024 Winter School in Mathematical Physics

Sunday 7 January 2024 - Friday 12 January 2024

Maison des Congrès

Scientific Programme

Maxim Zabzine, Equivariant localization in quantum field theory

This is an introductory lecture series on the use of equivariant localization techniques for path integrals, especially in the context of supersymmetric gauge theories.
I will explain some basics behind the Atiyah-Bott localization theorem, which allows for the exact calculation of certain integrals using only a semi-classical approximation. I will also discuss extensions of
this theorem to the infinite-dimensional setting, with a focus on low-dimensional supersymmetric gauge theories.
Towards the end of the lecture series, I will provide an overview of the subject's development over the last 15 years.

Eveliina Peltola, Interplay of Schramm-Loewner evolution curves with conformal field theory

In planar random geometry, a plethora of conformally invariant objects has emerged in the recent decades. Among these, particularly fruitful have been random fractal curves derived from one-dimensional Brownian motion: Schramm-Loewner Evolutions (SLE), Conformal Loop Ensembles (CLE), and their variants. Originally, they were introduced in the context of critical models in statistical physics to understand conformal invariance and critical phenomena upon taking the scaling limit. Indeed, not only do these objects describe critical interfaces in such models, but they also carry a deep connection to conformal field theory (CFT) -- quantum field theory with conformal symmetry, conjecturally describing the full scaling limit of critical models. In these lectures, I will introduce models for conformally invariant random SLE paths, discuss their relation to critical models, CFT, and its algebraic content. (Note that these lectures reflect my personal perspective on this topic.)

Francis Brown, Feynman Integrals and Number Theory

This mini-course will be an overview of the theory of Feynman Integrals in Quantum Field Theory and how they relate to various aspects of number theory. Ever since multiple zeta values were first observed in Feynman integral calculations in the 1990's, the interaction between number theory and physics has continued to grow tremendously and has led to progress in both fields. Consequently, modern techniques for studying and computing Feynman integrals make intensive use of ideas from number theory and algebraic geometry, and leads to many interesting new problems in those areas.

In this course I will cover the following topics:

Parametric representations, graph polynomials.

Periods, geometric and cohomological interpretations of Feynman integrals.

Arithmetic, point counting and modular forms.

Mellin transforms, Apery recurrences and holonomic sequences.