String Theory (L24)

Professor N. Dorey

String theory is the quantum theory of interacting one-dimensional extended objects (strings). What makes it so appealing is that it's a quantum theory that includes gravity, thus providing the first tentative steps towards a full quantum theory of gravity. It has become clear that string theory is also much more than this. It is a framework in which to reinterpret problems in quantum field theory in terms of geometry, and acts as a crucible for new ideas in mathematics. This course provides an introduction to String Theory. We begin by generalising the worldline of a particle to the two-dimensional surface swept out by a string. The quantum theory of the embedding of these surfaces in space-time is governed by a two-dimensional quantum field theory and we shall study the simplest example – the bosonic string – in detail. An introduction to relevant ideas in Conformal Field Theory (CFT) will be given. The quanti- sation of the string will be studied, its spectrum obtained, and the relationship between states on the two dimensional CFT and fields in space-time will be discussed. We will see the necessity of the critical dimension of space-time. The path integral approach to the theory will be discussed. Fadeev-Popov methods will be introduced to deal with the redundancies that appear in the theory. Vertex operators will be introduced and scattering amplitudes will be computed at tree level. Perturbation theory at higher loops and the role played by moduli space of Riemann surfaces will be sketched. The course will focus on closed strings, but time permitting, open strings and the role of D- branes may be discussed. There may also be some discussion of more stringy phenomena such as symmetry enhancement and duality.

Prerequisites

Knowledge of the Quantum Field Theory course in Michaelmas term is assumed. Advanced Quantum Field Theory will complement this course but will not be assumed.

Literature

1. M. Green, J. Schwarz and E. Witten, *Superstring Theory, Vol. 1: Introduction*, CUP 1987.
2. J. Polchinski, *String Theory, Vol. 1: An Introduction to the Bosonic String*, CUP 1998.
3. D. Tong, *Lectures on String Theory*, `https://arxiv.org/abs/0908.0333`

Additional support

Four examples sheets will be provided and four associated examples classes will be given. There will be a one-hour revision class in the Easter Term.