String Theory (L24)

R A Reid-Edwards

String theory is the quantum theory of interacting one-dimensional extended objects (strings). What makes the theory so apealing is that it is a quantum theory that necessarily contains gravitational interactions and therefore provides 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 has become a framework in which to understand problems in quantum field theory, to ask meaningful questions about what we expect from a quantum theory of gravity, and as a crucible yielding new ideas in mathematics.

This course provides an introduction to String Theory. We begin by generalising the worldline of a relativistic particle to the two-dimensonal surface swept out by a string (the world*sheet*). The quantum theory of the embedding of these surfaces in spacetime is goverened 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 two-dimensional Conformal Field Theory (CFT), such as the operator product expansion and the Virasoro algebra, will be given. The quantisation of the string will be studied, its specturm obtained, and the relationship between physical states of the two dimensional CFT and fields in spacetime will be discussed. We will see the necessity of the critical dimension of spacetime.

The path integral approach to the theory will be discussed and the Fadeev-Popov and BRST methods will be introduced to deal with the redundanceies 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.

Time permitting, we will discuss open strings (worldsheets with boundaries) and D-branes. The physics of strings on circles and higher dimensional tori will be discussed and stringy phenomena such as duality and corrections to field theory may also be discussed.

Pre-requisites

Knowledge of the Quantum Field Theory course in Michaelmas term is assumed and some familiarity with General Relativity is helpful. Advanced Quantum Field Theory will complement this course but will not be assumed.

Literature

1. Polchinski, *String Theory: Vol. 1: An Introduction to the Bosonic String*, CUP 1998
2. Green, Schwarz and Witten, *Superstring Theory: Vol. 1:Introduction* CUP 1987.
3. Lust and Theisen, *Lecture Notes in Physics: Superstring Theory*, Springer 1989. (Note there is also a more recent expanded edition witten with Blumenhagen).
4. David Tong, *String Theory*, arXiv: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.