String Theory (L24)

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String theory is the quantum theory of interacting one-dimensional extended objects (strings). What makes the theory so appealing is that it is a quantum theory that 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 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 spacetime 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 quantisation of the string will be studied, its spectrum obtained, and the relationship between states on 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. Fadeev-Popov and BRST methods will be introduced to deal with the redundenceies 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.

Pre-requisites

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. 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 written 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 revision class in the Easter Term.