

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 test bed 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. Time permitting we will discuss boundary conditions and D-branes.

The path integral approach to the theory will be discussed in detail. Fadeev-Popov and BRST 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.

Time permitting, RNS supersymmetry will be introduced on the worldsheet and the corresponding superstring theories sketched. There may also be some discussion of compactification 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 one-hour revision class in the Easter Term.