PHY 652: Introduction to conformal field theory

2024-25, semester - 1, Instructor - Apratim Kaviraj

Conformal field theories (CFTs) play a crucial role in the formulation of critical phenomena, quantum gravity and, in general, renormalization in quantum field theories. The goal of this course is to introduce the basics of CFTs, some applications/examples and related modern topics.

Lecture outline: 39 × (t = 50 min)

Topic	**Details**	***t***
Conformal symmetries	Group representations, operator classification, correlation functions	4
Operator product expansion	Radial quantisation, state-operator correspondence, conformal blocks	3
2d CFTs	Virasoro algebra, Ward identities, modular invariance, Coulomb gas formalism	4
Minimal models	Verma modules, fusion rules, Lee-Yang, Ising and Potts model	4
Deformations	Conformal perturbation theory, c-theorem, numerical techniques	3
General dimension	Projective null cone, Spinning operators, Reflection positivity, unitarity bounds and analytic properties	5
Examples in general d	Wilson-Fisher flow, large N CFTs, $\mathcal{N}$=4 Super Yang Mills	3
Symmetry broken setups	Boundaries and defects, thermal CFTs	4
Lagrangian-free methods	Numerical and analytical conformal bootstrap, Mellin transforms	4
Special topics	AdS/CFT, entanglement and thermalisation, scattering amplitudes and dispersion relations	5

Pre-requisites: PHY 681: Quantum field theory - 1.

Evaluation: Assignments [60%]. Endsemester examination will involve submission of a term paper [10%] and a viva [30%].

References:

- *Conformal Field Theory* , Francesco, Mathieu, Senechal;
- *Lectures on Liouville Theory and Matrix Models*, Zamolodchikov brothers;
- *TASI Lectures on the Conformal Bootstrap*, David Simmons-Duffin;
- *EPFL Lectures on Conformal Field Theory in D >= 3 Dimensions*, Rychkov;
- *Scaling and Renormalization in Statistical Physics*, John Cardy;
- *Selected Topics in Analytic Conformal Bootstrap:* A Guided Journey, Bissi, Sinha, Zhou.