Quantum Fields and Fundamental Forces

Special Topics Lectures 2016

5 June to 16 June 2017

Dr. Louise Anderson

Localisation and Matrix Models

The tool of supersymmetric localisation enables us to, under favourable conditions, to compute observables in (supersymmetric) quantum field theories exactly. In this course, we will review the basics of localisation, what these "favourable conditions" mean, and how we can approach the resulting matrix models.

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Prof. Joao Magueijo

Cosmological Fluctuations in the Early Universe

I provide a simple introduction to the production of fluctuations (vacuum and thermal) in the early universe. After presenting the general formalism, I review the simplest inflationary models, moving on to more complex ones. I then review bimetric varying speed of light theories, explaining how they are somewhat related to DBI inflation algebraically but not philosophically. Finally I review the concept of dimensional reduction in the UV, showing how it can be turned into a mechanism for generation of primordial fluctuations.

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Prof. Toby Wiseman

Introduction to AdS/CFT

I will give a pedagogical review of the AdS/CFT conjecture. I will begin with a brief overview of the conjectured duality between certain quantum field theories and quantum theories of gravity (or strings) where spacetime is dynamical. I will emphasise that this gives new ways to discuss the problem of quantum gravity, and provides fascinating new tools to study certain strongly coupled field theories using geometry. I will then give a brief introduction into the relevant basics of conformal field theory (CFT) and then move on to discuss the Anti deSitter spacetime (AdS). Using these discussions I will state in some detail how the duality is realised as an equality between the CFT and gravity partition functions. I will discuss the example of a bulk scalar and its dual description in detail. I will end by discussing how the duality works for the bulk metric, and how to implement finite temperature in the duality, and the role that black holes play.

I will also distribute simple problems (and solutions) for students interested in performing some basic computations in this area.

Dr. Hagen Triendl

Supergravity and Flux Compactifications

Ten-dimensional superstring theory can be related to four-dimensional theories at low energies by compactification. The question which four-dimensional theories can emerge from string theory has been a major topic of research for several decades now.

I will give an introduction to the topic of compactifications and fluxes in string theory and the relation to effective four-dimensional supergravity descriptions. Knowledge of the material from the courses on supersymmetry and on string theory will be advantageous.

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Dr. Andrew Tolley

Effective Field theories for Cosmology

The theories we use to describe the universe, such as inflation, dark energy are all non-renromalizable since at the very least they necessarily include gravity. Nevertheless they can be consistently quantized as low energy effective field theories. We will discuss how to deal with non-renormalizable interactions in practice, and how to construct effective field theories in situations were time dependence is spontaneously broken. In connection with this we will review the `in-in' or Schwinger-Keldysh formalism. These techniques will then be applied to effective field theories of inflation, dark energy and modifications of gravity. Given time we may discuss constraints on low energy effective field theories such that they have a UV completion.

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Prof. Carl Bender
Asymptotics in Physics

Perturbative analysis of physical problems almost invariably leads to (divergent) asymptotic series. In these lectures we examine the fundamental reason why perturbation series diverge and we will show how to sum such series to obtain finite and physically meaningful results.