Introduction to Quantum Field Theory
Course Outline

July 9, 2015

1 Course Meeting Times

We will meet in the Theory Department's meeting room on Wednesdays and Fridays from 1:30 pm - 3:00 pm. The course will take place from July 29th until August 14th.

2 Prerequisite

This course requieres that you have taken a graduate level class on Quantum Mechanics.

3 Course Description

Quantum Field Theory (QFT) is the mathematical framework used to describe the laws governing fundamental particle interactions. Field theory is an extension of Quantum Mechanics (QM) that deals with system consisting of an infinite number of degrees of freedom. It was developed to consistently merge quantum mechanics with the theory of special relativity in the late 1920's by P.A.M Dirac.

This course will help us understand the need for Field Theory, after reviewing some historical accounts. We will then review concepts that exist in classical field theories and then proceed to canonically quantize a self interacting scalar field. Before quantizing fields with spin 1/2, we will introduced the path integral formalism and use is as an alternate method of quantization. Halfway through the course will will introduce the concept of renormalized field theories and the process by which a theory is renormalized. This part will end with a brief discussion of the renormalization group. Last but not least, we will introduce the concept of gauge symmetries and how gauge field theories such as QED are quantized.

Throughout out this course we will use as a primary tool the theory of a self interacting scalar (spin 0) field to understand certain concepts such as Renormalization. This theory has the advantage of being simple and carries all of the essential features of QFT.

We will be using various book and review notes throughout the course, references which are listed at the bottom of this document. The list provides the backbone of the course, but by no means is extensive. More references may be introduced at the beginning of a lecture to compliments discussions.

4 Course Syllabus

1. The Need for Field Theory:
    - A bit of history.
    - Review of Lorentz invariance.
    - Classical Field Theory.
    - Symmetries and conserved charges.
2. Canonical Quantization of Scalar Fields:
    - Quantization.
    - Spin Statistics Theorem.
    - The LSZ Reduction Formula.
3. The Path Integral:
    - From QM to QFT.
    - The Integral for free and interacting scalar field theory..
    - Quantization of spin 1/2 particles.
4. Renormalization:
    - Renormalization of a scalar field theory.
    - Regularization scheme.
    - Renormalizabilty.
    - The Renormalization Group.

5 Exercises

Homework will be assigned with exercises that will compliment the class discussion. However, there will be no grading, and feedback from the instructor is strictly at the student's request.

References

[1] M. Srednicki, "Quantum field theory," Cambridge, UK: Univ. Pr. (2007) 641 p

[2] Michael E. Peskin and Daniel V. Schroeder, "An Introduction to Quantum Field Theory," Westview Press (1995) 864 p

[3] Ta-Pei Cheng and Ling-Fong Li, "Gauge Theory of Elementary Particle Physics," Oxford University Press, USA (1984) 548 p