PHY781: High Energy Physics

(Advanced Quantum Field Theory)

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Prerequisites: PHY685 (Quantum Field Theory)

Summary: This is a second course on Quantum Field Theory (QFT). QFT is one of the fundamental tools of modern physics with broad ranging applications in all of theoretical physics including condensed matter physics, particle physics, and other areas of high energy physics.

This course is structured as follows. We first briefly cover quantization for constrained systems, and rederive aspects of Quantum Electrodynamics. We then consider classical aspects of Abelian and non-Abelian gauge theories. The second part introduces the path integral formulation and reconsiders the quantization of scalar, fermionic and electromagnetic theories in this formulation. We then use these methods for Yang-Mills theories. The last part of the course deals with renormalization. Answers to various processes in QFT often turn out to be infinite. Regularization and renormalization are used to extract physical answers out of these infinites. This course will lay out these formal procedures and show how to renormalize various QFTs.

Topics to be covered:

1. Introduction
2. Quantization of constrained systems
    a. Classification of constraints
    b. Dirac method of quantization
3. Classical aspects of gauge theories.
4. Functional methods
    a. Path integrals for quantum mechanics
    b. Path integral quantization of scalar fields, fermions and electrodynamics
5. Quantization of Yang-Mills theories
    a. Path integrals, Fadeev-Poppov ghosts.
    b. BRST quantization.
6. Renormalization
    a. Systematics of renormalization
    b. Renormalization group

Evaluation*:

- Assignments/Take home examinations: 50%
- Project: 50% (Report: 10%, End term presentation: 40%).

* *To be finalized after assessing number of students in class*

References: The course would be constructed out of several books and notes and will evolve depending on the students in the class. Below is a list of books that would be useful.

- M. Peskin and D. Schroeder: *An Introduction to Quantum Field Theory*
- S. Weinberg: *The Quantum Theory of Fields: Vol 1 and 2.*
- M. Scredniki: *Quantum Field Theory*
- L. Ryder: *Quantum Field Theory*
- A. Zee: *Quantum Field Theory in a Nutshell.*