PHYS6632: QUANTUM FIELD THEORY II

Instructor: Mirjam Cvetič, DRL 4N14, x 8153, email:cvetic@physics.upenn.edu

Fall 2025, MW: 8:30-10AM

(I) PURPOSE:

The course would cover a systematic perturbative calculations in quantum field theories based on local gauge invariance, with primary applications to elementary particle physics. The course will first briefly summarize quantum electrodynamics (QED) as a renormalized Abelian Gauge Theory. FurthermoreWe shall develop renormalization group for general renormalized quantum field theories and apply it to QED.

We shall focus then turn to the quantization of non-Abelian Gauge Theories (Fadeev-Popov quantization and BRST quantization) and apply it to quantum chromodynamics (QCD) and electroweak theory (EW), also referred to as the Standard Model (SM) of elementary particle physics. We shall develop the rigorous quantization and systematic renormalization in (non-)Abelian Gauge Theories, including the study of Ward-Takahashi identities. We shall further study the quantum field theory Spontaneous Symmetry Breaking (SSB) and Higgs Mechanism in (non-)Abelian gauge theories, and applications to the Standard Model.

Time permitting, the plan is to extend the scope of the course to develop the quantum field theory of N=1 supersymmetric non-Abelian gauge theories and applications to the Supersymmetric Standard Model.

(II) SPECIFIC TOPICS COVERED:

(A) Non-Abelian Gauge Theories

(i) group theory
(ii) Fadeev-Popov quantization via path-integral; BRST symmetry; systematic rirenormalization
(iii) Brief summary for QCD
(iv) Application to quantum chromodynamics (QCD)

(B) Spontaneous Symmetry Breaking in Non-Abelian Gauge Theories

(i) Higgs mechanism
(ii) quantization and renormalization
(iii) application to the Standard Model of electroweak interactions

(III) TEXT BOOKS:

(i) Main Text

Matthew Schwartz: Quantum Field Theory and the Standard Model;

(ii) Supplemental Text Michael Peskin and David V. Schroeder: Introduction to Field Theory,

(IV) GRADING: homework (50 %), take-home final (50 %)