

Quantum Field Theory–Spring 2010

Ling-Fong Li

This course will include the following topics:

Part I. Quantization of Field Theory

- 1) Preliminaries
 - a. Need for Field Theory
 - b. Special Relativity and Lorentz transformation
 - c. Action Principle
 - d. Noether's Theorem
- 2) Relativistic Wave Equations
 - a. Klein-Gordon Equation
 - b. Dirac Equation
 - c. Lorentz Group and its Representation
- 3) Canonical Quantization
 - a. Scalar Field
 - b. Fermion Field
 - c. Electromagnetic Field
- 4) Path Integral Quantization
 - a. Quantum Mechanics
 - b. Scalar Field Theory
 - c. Fermion Field and Grassmann Algebra
- 5) Interaction Theory and Feynman Rule

Part II. Theory of Renormalization

- 1) Renormalization in $\lambda\phi^4$ theory
 - a) Regularization schemes
 - b) Counter terms & BPH scheme
 - c) Power counting and renormalizability
- 2) Renormalization group
 - a. Callan-Symanzik equation
 - b. Renormalization equation in dimensional regularization
 - c. Effective coupling constant

Part III. Symmetry

- 1) Global symmetry
 - a. Conservation laws
 - b. Symmetry and renormalization
 - c. Anomaly
- 2) Local symmetry
 - a. Abelian gauge symmetry
 - b. Non-abelian symmetry
 - c. Quantization of gauge theories
- 3) Spontaneous symmetry breaking
 - a) Goldstone theorem
 - b) Higgs phenomena

Part IV. Standard Model of Electroweak Interaction

- 1) Construction of $SU(2) \times U(1)$ theory
 - a) Weak interaction before gauge theory
 - b) Choice of the group and tree unitarity
 - c) Gauge theory with leptons
 - d) Quarks masses and mixing
- 2) Phenomenology of Standard Model
 - a) Neutral current reactions
 - b) W and Z gauge bosons
 - c) Neutrino oscillations
 - d) Higgs particle

Part V. Theory of Strong Interaction--Quantum Chromodynamics

- 1) Parton Model and Scaling
 - a) Deep inelastic scattering
 - b) Bjorken scaling and light cone behavior
 - c) Parton model and scaling
- 2) QCD
 - a) Quark Model and color symmetry
 - b) Asymptotic freedom and Non-Abelian theory

- c) QCD Lagrangian
- d) Renormalization group analysis of scaling and scaling violation
- e) Quarkonium

Part VI. Grand unification

- a. SU(5) model
- b. Proton decay
- c. Baryon number asymmetry

References:

- 1) T. P Cheng and L. F. Li, "Gauge Theory of Elementary Particle Physics", Oxford University Press (1984).
- 2) M. Peskin and D. Schroeder, "An Introduction to Field Theory", Addison-Wesley (1995).
- 3) S. Weinberg, "Quantum Field Theory" Volume 1, (Cambridge University Press) (1995).
- 4) M. Srednicki, "Quantum Field Theory", (Cambridge University Press) (2007).