Quantum Field Theory I, PHY6648

SYLLABUS

0. Introduction
   1. Problems with Relativistic quantum mechanics (MS 1)
   2. Lorentz invariance (MS 2)
   3. Free scalar field (MS 3)
   4. A first look at interacting scalar field

I. Time Dependent Perturbation Theory
   5. General formalism
   6. Scattering in an external field: Born approximation
   7. Perturbation theory for time ordered products.
   8. Propagators

II. Path History Quantization
   9. General formalism (MS 6, 7)
   10. Classical limit
   11. Time ordered products
   12. Gaussian path integrals (MS 8)
   13. Anticommuting fields
   14. Interacting Scalar fields (MS 9)

III. Feynman rules for scalar field theory (MS 10, 11, 12)

IV. Dirac Equation
   15. Dirac equation for the free electron (MS, 1: pp 7-10)
      (a) Lorentz Invariance (MS, 2,33)
      (b) Energy-momentum and Spin
      (c) Particles and Holes
   16. Second Quantization
      (a) General formalism (MS, 1: pp 11-13)
      (b) Application to Dirac equation
   17. Weyl fermions: Left and right handed fermions (MS, 34,35)
   18. Charge Conjugation and Majorana Fermions (MS,36)
   19. Parity, and Time Reversal.

V. Representations of the Poincarè Group for General Spin (MS 33)

20. Little group constructions
21. Finite dimensional (non-unitary) representations of the Lorentz Group.
22. Two component spinor formalism. (MS, 34,35)

VI. External Electromagnetic Fields

1. Time Dependent Quantum Theory
2. Green Functions, Feynman Rules
3. Scattering in an External Field
   (a) Reduction Formalism (MS 5, 41, 56)
   (b) Calculation of cross sections —Mott Scattering
4. Vacuum polarization
5. Charge renormalization
6. Vacuum energy in a weak static field; Pair creation in a weak external field.
7. Constant fields of arbitrary strength

VII. Quantization of the Free Electromagnetic Field

1. Canonical Operator Quantization (MS 54, 55, 56)
2. Path Integral Quantization (MS 57)
3. Dirac field and Path Integrals (MS 43 44)
4. Gauge-fixing—Fadeev-Popov prescription

VIII. Quantum Electrodynamics

1. Derivation of Feynman rules (MS 58)
2. Compton, Moller, and Bhaba Scattering (MS 59)
3. Pair production
4. Higher order Processes (MS 62)
   (a) Ultraviolet divergences
   (b) Ward identities (MS 67, 68)
5. Mass and Charge Renormalization
6. Anomalous Magnetic Moment; Lamb shift; $\pi_0 \to 2\gamma$
7. Positronium and Quarkonium
8. Infrared Divergences; Soft Photon Bremstrahlung; Gauge Invariance
9. Renormalization Group and Callan-Symanzik Equation