TENTATIVE SYLLABUS

This is a tentative schedule of what we will cover in the course. It is subject to change, often without notice. These will occur in response to the speed with which we cover material, individual class interests, and possible changes in the topics covered. Use this plan to read ahead from the text books, so you are better equipped to ask questions in class.

INTRODUCTION

• **Classical Field Theory:** Lagrangian density. Example: Continuum limit of a one dimensional lattice. Lorentz invariance. Locality and causality. Equations of motion.

  **Literature:**
  1) M.E. Peskin, D.V. Schroeder: Quantum Field Theory (Chapter 2.2)
  2) H. Goldstain: Classical Mechanics, Addison-Wesley, 3d edition (Chapters 13.1, 13.2)

• **Noether’s Theorem:** Symmetry. Noether’s theorem. Energy-momentum tensor. Examples.

  **Literature:**
  1) M.E. Peskin, D.V. Schroeder: Quantum Field Theory (Chapter 2.2)
  2) H. Goldstain: Classical Mechanics, Addison-Wesley, 3d edition (Chapters 13.3, 13.5, 13.7)

• **Klein-Gordon Field:** Hamiltonian formalism. Quantization. Fock space. Spectrum. Causality and local commutativity in QFT. Feynman propagator.

  **Literature:**
  1) M.E. Peskin, D.V. Schroeder: Quantum Field Theory (Chapters 2.3, 2.4)
  2) H. Goldstain: Classical Mechanics, Addison-Wesley, 3d edition (Chapters 13.4, 13.6)
THE DIRAC FIELD


**Literature:**
1) M.E. Peskin, D.V. Schroeder: Quantum Field Theory (Chapters 3.1, 3.2, 3.4)


**Literature:**
1) M.E. Peskin, D.V. Schroeder: Quantum Field Theory (Chapters 3.1-3.3)

- **The quantized Dirac field:** The canonical quantization of the Dirac field. The relation between the spin and the statistics. The Dirac propagator. Grassmann numbers.

**Literature:**
1) M.E. Peskin, D.V. Schroeder: Quantum Field Theory (Chapter 3.5)


**Literature:**
1) M.E. Peskin, D.V. Schroeder: Quantum Field Theory (Chapters 3.6)

PERTURBATION THEORY

- **Interacting fields:** Perturbative QFT. Relevant, marginal and irrelevant perturbations. Examples: $\phi^4$-theory, Yukawa theory, QED.

**Literature:** 1) M.E. Peskin, D.V. Schroeder: Quantum Field Theory (Chapter 4.1)


**Literature:** 1) M.E. Peskin, D.V. Schroeder: Quantum Field Theory (Chapters 4.2-4.4)


**Literature:** 1) M.E. Peskin, D.V. Schroeder: Quantum Field Theory (Chapters 10.1, 10.2)

- **Renormalized perturbation theory:** renormalization programm. Interacting fields in $d$-dimensions. Dimensional regularization. Renormalization schemes. Renormalization at the leading order in $\phi^4$-theory.

**Literature:** 1) M.E. Peskin, D.V. Schroeder: Quantum Field Theory (Chapters 10.1, 10.2, 7.7 (pp.249-251))


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1 Advanced Book Classics

Literature: 1) M.E. Peskin, D.V. Schroeder: Quantum Field Theory (Chapters 12.2, 12.3)

SCATTERING THEORY


Literature: 1) M.E. Peskin, D.V. Schroeder: Quantum Field Theory (Chapters 7.1, 7.2, 4.5, 4.6);
2) S. Weinberg, The Quantum Theory of Fields, Cambridge University Press, Vol.1 (Chapters 3.1, 3.2, 3.4, 3.5);
3) C. Itzykson, J.-B. Zuber, Quantum Field Theory, McGraw-Hill International Editions [IZ], Vol.1 (Chapter 5);


Literature: 1) M.E. Peskin, D.V. Schroeder: Quantum Field Theory (Chapters 4.5-4.7);

Elementary processes of QED: Feynman Rules for QED. The Coulomb Potential. $e^+ + e^- \rightarrow \mu^- + \mu^+$ and $e^- + \mu^- \rightarrow e^- + \mu^+$ cross sections. Compton scattering.

Literature: 1) M.E. Peskin, D.V. Schroeder: Quantum Field Theory (Chapters 1, 4.8, 5.1-5.3, 5.5);


Literature: 1) M.E. Peskin, D.V. Schroeder: Quantum Field Theory (Chapters 5.4, 7.3);
QED

  **Literature**: 1) M.E. Peskin, D.V. Schroeder: Quantum Field Theory (Chapters 10.1, 10.3, 7.5);

- **Radiative corrections**: Electron-photon vertex and two particle form factors of the current. Schwinger’s correction. Infrared divergencies.
  **Literature**: 1) M.E. Peskin, D.V. Schroeder: Quantum Field Theory (Chapters 6.1-6.5, 7.3);

  **Literature**: 1) M.E. Peskin, D.V. Schroeder: Quantum Field Theory (Chapters 7.1 (pp.217-222), 7.4;

- **UV asymptotics**: Vacuum polarization. Callan-Symanzick equation. Running coupling constant. Landau pole.
  **Literature**: 1) M.E. Peskin, D.V. Schroeder: Quantum Field Theory (Chapters 7.5, 12.2);