Physics 619: Fields II **Fall 2016**

PREREQUISITES

This course is a continuation of 618 (Fields I). At Spring you have used Srednicki's textbook. It was covered almost all of Part I (spin 0), and most of Part II (spin 1/2). Specifically, in Part II chapters 34-37, 39, 40, 42-45, 48, 51, 52. There were also couple of lectures on critical phenomena, the Ising model and ϕ^4 theory which is not in Srednicki's book. If you did not take Fields I, it is your responsibility to do background reading to make sure you understand the concepts in this course. Specifically, I will assume that you are familiar with the following concepts:

- **Canonical quantization of scalar and spin-$\frac{1}{2}$ fields**
(M. Peskin, D. Schroeder: Chs. 2,3)
- **Renormalized perturbation theory** (ϕ^4 and Yukawa theories)
(PS: Chs. 4.1-4.4, 4.7, 10.1-10.2)
- **Path-integral quantization of scalar and spin-$\frac{1}{2}$ fields** (both Minkowski and Euclidian forms)
(PS: Chs. 9.1-9.3, 9.5)
- **Renormalization Group**
(PS: Chs. 12.1-12.3)
- **General form of the spectrum in QFT, S-matrix, LSZ formalism**
(PS: Chs. 4.5, 4.6, 7.1-7.3)
- **Spontaneous Symmetry Breaking**
(PS: Ch. 11.1)

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.

Quantization of the EM field

• **Canonical quantization:** General aspects of quantization of systems with constraints. Brief overview of the Lorentz group. Maxwell's equations. EM field as a dynamical system with constraints. Quantization in the Coulomb gauge.
Literature: 1). M. Srednicki: Quantum Field Theory (Chapters 33, 54-56).

• **Covariant path integral quantization**: Euclidean path integral. Gauge group. Gauge fixing conditions. Faddeev-Popov trick. Feynman propagator.
Literature: 1) M.E. Peskin, D.V. Schroeder: Quantum Field Theory (Chapter 9.4).

Quantum Electrodynamics

• **Lagrangian and Feynman rules**: Feynman rules for QED. Gauge invariance of the scattering amplitudes. Electron vertex function (formal structure).
Literature: 1). M. Srednicki: Quantum Field Theory (Chapters 58-59); 2) M.E. Peskin, D.V. Schroeder: Quantum Field Theory (Chapters 4.7, 5.1, 6.2).

• **One-loop radiative corrections:** Electron propagator. Electron vertex function. Ward-Takahashi identity. Magnetic moment of the electron. Infrared divergence.
Literature: 1) M.E. Peskin, D.V. Schroeder: Quantum Field Theory (Chapters 6.3-6.5, 7.1, 10.3); 2). M. Srednicki: Quantum Field Theory (Chapters 62-64, 67).

• **Renormalized Perturbation Theory:** Vacuum polarization: formal structure. Renormalized action and counterterms. Pauli-Villars and dimensional regularization. Vacuum polarization: evaluations.
Literature: 1) M.E. Peskin, D.V. Schroeder: Quantum Field Theory (Chapters 10.1, 10.3); 2). M. Srednicki: Quantum Field Theory (Chapter 62).

• **Renormalization group in QED:** Radiative corrections to the Coulomb law. Callan-Symanzik equation. β-function.
Literature: 1) M.E. Peskin, D.V. Schroeder: Quantum Field Theory (Chapters 10.3, 12.3); 2). M. Srednicki: Quantum Field Theory (Chapter 66).

Non-Abelian Gauge Theories

• **Gauge invariance:** Geometry of gauge invariance. Wilson loop. Yang-Mills Lagrangian. Basic facts about Lie algebras. Yang-Mills for an arbitrary compact group.
Literature: 1) M.E. Peskin, D.V. Schroeder: Quantum Field Theory (Chapters 15.1-15.4); 2). M. Srednicki: Quantum Field Theory (Chapters 69, 70).

• **Quantization of non-Abelian gauge theories:** Path integral quantization. Feynman rules. Ghosts and unitarity. BRST symmetry.
Literature: 1) M.E. Peskin, D.V. Schroeder: Quantum Field Theory (Chapters 16.1-16.3); 2). M. Srednicki: Quantum Field Theory (Chapters 71, 72, 74).

• **Asymptotic freedom:** Renormalization in the Y-M theory. One-loop divergencies. β-function. Quantum Chromodyanamics. Background field method. Functional determinants. Seley coefficients.
Literature: 1) M.E. Peskin, D.V. Schroeder: Quantum Field Theory (Chapters 16.5-16.7, 17.1-17.2); 2). M. Srednicki: Quantum Field Theory (Chapter 73, 78).

Axial currents in gauge theories

• **Axial current in two dimensions**
Literature: 1) M.E. Peskin, D.V. Schroeder: Quantum Field Theory (Chapter 19.1);

• **Bosonization in two dimensions:** Schwinger model

• **Axial current in four dimensions**
Literature: 1) M.E. Peskin, D.V. Schroeder: Quantum Field Theory (Chapters 19.2); 2) M. Srednicki: Quantum Field Theory (Chapter 73, 76, 77).

• **Goldstone bosons and chiral symmetries in QCD**
Literature: 1) M.E. Peskin, D.V. Schroeder: Quantum Field Theory (Chapter 19.3); 2) M. Srednicki: Quantum Field Theory (Chapter 83).

Gauge theories with spontaneous symmetry breaking

• **Higgs mechanism**

Literature: 1) M.E. Peskin, D.V. Schroeder: Quantum Field Theory (Chapter 20.1); 2) M. Srednicki: Quantum Field Theory (Chapter 84).

- **Quantization of spontaneously broken gauge theories**

Literature: 1) M.E. Peskin, D.V. Schroeder: Quantum Field Theory (Chapters 21.1); 2) M. Srednicki: Quantum Field Theory (Chapters 85, 86).

- Glashow-Weinberg-Salam theory of weak interactions

Literature: 1) M.E. Peskin, D.V. Schroeder: Quantum Field Theory (Chapters 20.2); 2) M. Srednicki: Quantum Field Theory (Chapters 87-89).