DRAFT FOR DISCUSSION (10/11/00)

Physics 520/521
Advanced Quantum Mechanics / Introductory Quantum Field Theory

The aim of this two quarter sequence is to provide an introduction to field theoretic methods used in atomic, condensed matter, nuclear and particle physics to describe many-particle systems, both non-relativistic and relativistic. The class focuses on fundamentals (e.g how to make quantum mechanics consistent with special relativity) and introduces diagrammatic methods of perturbation theory which are very general. The applications chosen to illustrate these methods will vary from instructor to instructor.
The following is the approximate syllabus to be used in 2000/1. The ordering of subjects is intended to get to new material (relativistic QM) quickly, as is different from that used in the last few years. Items in *italics* are applications.
The text for the two quarters is

M. Peskin and D. Schroeder, *An Introduction to Quantum Field Theory.*

This book does not, however, cover all of the material in the syllabus, in particular "second quantization" and the applications to atomic physics. For these I hand out some notes, problems and solutions written by Larry Yaffe, as well as suggest alternative readings.

Ph520/521 Approximate Syllabus (Fall and Winter Qtrs.):

1. Second Quantization

   Bose & fermi creation and annihilation operators, Fock space, mode expansions, observables. *Chemical potential, Bose,Einstein condensation including interactions.*

2. Free Relativistic Bosons

   Quantized scalar fields, Lorentz invariance, causality.

3. Free Relativistic Fermions

   Quantized spinor fields, Dirac equation, charge conjugation and antiparticles, spin-statistics connection. *Applications, helicity and neutrinos..*

4. Interacting Relativistic Bosons

   Correlation functions, diagrammatic perturbation theory, Wick's theorem, Feynman diagrams. *Application, calculating scattering amplitudes and cross sections,*

5. Photons and Atoms

   Quantized electromagnetic fields, free photons, interactions with non-relativistic matter, photon emission & absorption. *Classical limit, atomic lifetimes, light scattering.*

6. Basic Quantum Electrodynamics

   Elementary processes, *Compton scattering, pair production*, photon propagators, gauge choices, *electron,positron scattering.*

7. Basic Renormalization

   Physical *vs.* bare parameters, ultraviolet and infrared cutoffs, renormalizable theories. *Non,relativistic radiative corrections, mass renormalization, Lamb shift.*