Massachusetts Institute of Technology

Physics 8.514 | Physics Department | Fall 03

Many-body phenomena in condensed matter and atomic physics

Lectures: Tu, Thr, 9:30-11, in Rm. 26-168, by Prof Leonid Levitov
http : //www.mit.edu/people/levitov/8514

Prerequisite: Statistical Mechanics and Quantum Mechanics, introductory level courses

The aim of the course is two-fold. First, we shall discuss topics of interest for both condensed matter and atomic physics, focussing on the effects of quantum statistics, interactions, and correlations in many-particle systems. Our second goal will be to provide a gentle introduction to the methods of quantized fields and their applications in many-body physics. We shall try to emphasize the physical and visualizable aspects of the subject. While the course is intended for students with a wide range of interests, many examples will be drawn from condensed matter physics.

Course topics (tentative):

- Bose condensates (quasiparticles, collective modes, superfluidity, vortices);
- Fermi gases and liquids, collective excitations;
- Cooper pairing (BCS theory, off-diagonal long-range order, superconductivity);
- Atom interacting with an optical field;
- Lamb shift, Casimir effect;
- Dicke superradiance;
- Quantum transport and wave scattering in disordered media, localization;
- Tunneling and instantons;
- Macroscopic quantum systems, coupling to a thermal bath;
- Spin-boson model, tunneling and localization;
- Kondo effect;
- Spin dynamics and transport in gases and solids;
- Cold atoms in optical lattices;
- Quantum theory of photodetection and electric noise

In this course we shall develop theoretical methods suitable for the description of the many-body phenomena, such as Hamiltonian second-quantized operator formalism, Greens functions, path integral, functional integral, and the quantum kinetic equation. The concepts to be introduced include, but are not limited to, the random phase approximation, the mean field theory (aka saddle-point, or semiclassical approximation), the tunneling dynamics in imaginary time, instantons, Berry phase, coherent state path integral, renormalization group.

Recommended texts:

Michael Stone, *The Physics of Quantum Fields,* (2000, Springer)