Physics 832: Quantum Many-Body Physics Fall 2010

Lecture: TuTh 2:00–3:15 in Phy 2202 by Michael Levin (Office: Phy 2220).

Prerequisites: Quantum mechanics (Physics 402), Statistical physics (Physics 404).

Philosophy: This course will introduce some of the basic tools, concepts, and physical pictures necessary for understanding a variety of quantum many-body phenomena. I will emphasize the conceptual rather than the calculational aspects of the subject, and will use an approach based on path integrals, mean field theories, and semi-classical approximations. In addition to classic subjects such as superfluidity and Fermi liquid theory, I will discuss some modern topics in quantum condensed matter physics, including (hopefully) fractional quantum Hall states, topological insulators, and "exotic" spin systems with topological order or emergent gauge bosons.

Course topics (tentative):

- One particle physics: Single particle path integral, Linear response and correlation functions, Berry's phase, Tunneling, Instantons
- Boson systems: Second quantization, Mean field theory, Many-body path integral, Superfluidity, Kosterlitz-Thouless transition, Renormalization group
- Fermion systems: Free fermion systems, Hartree-Fock approximation, Fermi liquid theory
- Gauge theory: Z_2 gauge theory, U(1) gauge theory, Boson-vortex duality, Confinement
- Quantum Hall effect: Integer quantum Hall states, Fractional quantum Hall states, Fractional statistics, Edge excitations
- Topological insulators: 2D and 3D cases, Z_2 classification
- Topological phases: Definition and physical characterization, Exactly soluble examples, Emergent gauge theory

Recommended Texts: Xiao-Gang Wen, Quantum Field Theory of Many-Body Systems.

Problem sets: Approximately one a week.

Grading: Grades will be given based on the problem sets.