Syllabus Course 620
Many Body Physics I
Fall 2019

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Course Description

We will develop the foundations of thermal non-relativistic many body physics. Starting from the many particle Schrödinger equation and statistical mechanics, this course will teach you the framework to describe the collective motion of a large ($\sim 10^{23}$) number of particles. You will learn how to solve problems using advanced field theoretic tools and develop intuition for the complex behavior of many particle systems. Despite the fact you have already learned the basic fundamental laws that dictate the motion of each individual particle we will see how new but equally fundamental "laws" emerge due to the large scale complexity of the problem. "More is Different" P. W. Anderson, Science (1972).

Course Requirements

- Homework 70%
- Final Paper 20%
- Final Presentation 10%

The paper will go into depth on a modern topic or something we didn't cover that the student finds interesting in many body physics. I will provide a list of suggestions for the paper. The presentation will present the topics in their paper which will most likely be in powerpoint format (if you want to give a "chalk talk" you must talk to me first).

Books

When appropriate we will supplement this with other texts that have some sections that I feel are more in depth.

- Main text: "Condensed Matter Field Theory" by Altland and Simmons.
- For second quantization will use "Quantum Many-Particle Systems" by Negele and Orland.
- For perturbation theory and response functions this will be supplemented by "Quantum Theory of Many-Particle Systems" by A.L. Fetter and J.D. Walecka; and "Many-Particle Physics" by Gerald D. Mahan.

Other great texts:
Coleman, "Introduction to Many Body Physics"
Feynman, "Statistical Mechanics" and his PhD Thesis
Shankar, "Quantum Field Theory and Condensed Matter"
Fradkin, "Field Theories of Condensed Matter Systems"

Course Content

1. Introduction to quantum fields
    - Philosophy of a condensed matter theorist
    - Classical phonons
    - Quantum phonons
2. Second Quantization
    - Many-particle quantum mechanics
    - Derivation of creation and annihilation operators
    - Applications of second quantization
3. Path Integrals
    - Single Particle
    - Coherent states
    - Functional integral of bosons and fermions
4. Greens functions and perturbation theory
    - Analytic structure of the Green function
    - Feynman diagrams
    - Finite temperature
    - RPA theory
    - Quasiparticles
    - Response functions