Brief description of Many-body theory course at the school of physics, IPM

Condensed matter physics deals with a wide variety of topics ranging from gas to liquids and solids, as well as plasma where owing to the interplay between the motions of a tremendous number of electrons and nuclei, rich varieties of physical phenomena occur. Condensed matter theory is a very successful theory.

The aim of this course is to cove **the traditional condensed matter theory**, such as perturbation theory and Landau's symmetry breaking theory and renormalization group theory, and **the modern condensed matter theory**, quantum field theory of many body systems. We are seeing an emergence of a new theme in the many-body theory of condensed matter systems. The new paradigm may even have an impact on our understanding of fundamental questions of nature.

In this course, we will be following two books:

1) Condensed Matter Field Theory, by A. Altland and B. Simons, Second Edition, Cambridge 2010

2) Many-Particle Physics, by Mahan, Third Edition, Plenum Publishers (2000).

Here is a brief summary of what we will cover in the first semester:

1) From particles to fields: where we discuss most basic principles namely, canonical conjugate relation, symmetry and conservation law, quantum electrodynamics and the variation principle.

2) Second quantization where make the passage from the wave-function to the field operator. Some applications of second quantization like, Jordan Wigner representation, Hubbard model, non-interacting electron gas and one dimensional electron liquid systems will be discussed.

3) Green's function at zero temperature as a fundamental correlation of quantum fields. We develop the tool of Feynman diagram for visualizing and calculating many body processes.

4) Green's function at nonzero temperature. By replacing $it \to \tau$ we will see how to extend quantum field theory to finite temperature (a link between fluctuations and dissipation)

5) Functional filed integral where we will construct the many-body path integral and its bosonization.

6) Broken symmetry and collective phenomena where we discuss Bose-Einstein condensation, superfluidity and superconductivity.

NOTICE:

i) For non-IPM students there is the possibility of formally registering for the course as a "guest student". Please arrange the formal details with the physics department office.

ii) I anticipate that all the students, people who have formally registered or otherwise alike, to attend the lectures regularly and more importantly take the problem sets seriously.

Yours faithfully,
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