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. The electron liquid paradigm is also at the basic of most of our current understanding of the physical properties of electronic systems.

In this course, we will be following two books:

1) **Quantum Theory of the Electron Liquid, by Giuliani and Vignale, Cambridge 2005**
2) **Condensed Matter Field Theory, by A. Altland and B. Simons, Second Edition, Cambridge 2010**

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

1) **Introduction to the Electron liquid**: where we discuss most basic principles namely, Jellium mode, exchange and correlation energies, the Wigner crystal and equilibrium properties of the electron liquid.
2) **Linear response theory**: where we discuss the theory of linear response theory, the fluctuation-dissipation theorem, collective modes, density and current response theories, spin response theory.
3**) Linear response of interacting electron liquid systems**: where we discuss the density-density response of non-interacting systems, Mean field theory of linear response, screened potential and dielectric function, the random-phase-approximation, the many body local field theory, effective interactions in the Fermionic liquid, the dynamical local field factors, dynamical structure factors, generalized elasticity theory.
4) **Fermi liquid theory**: where we discuss the landau Fermi liquid, macroscopic theory of Fermi liquid, quasi-particle properties, the self-energy, the GW approximation.
5) **Many-body physics in graphene (mono- and bilayer) systems**: where we discuss the linear response of massless Dirac fermions, Thomas-Fermi and Hartree-Fock theories in graphene, quasi-particle properties within GW theory, thermodynamic properties and collective models in graphene systems.
6) **Broken symmetry and collective phenomena:** where we discuss symmetry, order parameter, Goldeston theorem, hydrodynamic of simple liquids, spontaneous symmetry breaking, 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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