PHY661: Advanced Solid State Physics II 4 CH (L60+T20)

Nature of the course: Theory Full Marks: 100 Pass Marks: 50

Course Description:

This course aims at providing students with basic knowledge and skill in theoretical as well as experimental aspects of Solid State Physics.

Objectives:

- To acquaint student with the theoretical and experimental methods in Solid State Physics.
- To prepare them in developing skill to pursue further study and research in the field of physics.

Course Content:

1. **Density functional theory:** **[6 hours]**
   - 1.1 The Hohenburg-Kohn theorem
   - 1.2 Kohn-Sham formalism
   - 1.3 Local density and the generalized gradient approximation
   - 1.4 Electronic structure calculations

2. **Screening and plasmons;** **[8 hours]**
   - 2.1 Thomas-Fermi screening
   - 2.2 Plasma oscillations
   - 2.3 Linear response theory
   - 2.4 Dielectric response function
   - 2.5 Stopping power of a plasma

3. **Bosonization:** **[6 hours]**
   - 3.1 Luttinger liquid
   - 3.2 Pair binding
   - 3.3 Excitation spectrum

4. **Electron-lattice interaction:** **[8 hours]**
   - 4.1 Harmonic chain
   - 4.2 Acoustic phonons
   - 4.3 Electron-phono interaction
   - 4.4 Ultrasonic attenuation
   - 4.5 Electrical conduction
   - 4.6 Phono drag
   - 4.7 Sound propagation

5. **Superconductivity:** **[16 hours]**
   - 5.1 Superconductivity: phenomenology
   - 5.2 Electron-phono effective interaction
   - 5.3 Model interaction
   - 5.4 Cooper pairs
   - 5.5 Fermi-liquid theory
   - 5.6 Pair amplitude

5.7 BCS ground state
5.8 Pair fluctuations
5.9 Ground state energy
5.10 Critical magnetic field
5.11 Energy gap
5.12 Quasi-particle excitation
5.13 Thermodynamics
5.14 Experimental applications
5.15 Josephson Tunneling

6. Quantum phase transition: [8 hours]

6.1 Quantum rotor model
6.2 Scaling
6.3 Mean-field solution
6.4 Landau-Ginzburg theory
6.5 Transport properties
6.6 Experiments

7. Quantum Hall Effect: [8 hours]

7.1 What is quantum about Hall effect
7.2 Landau levels
7.3 Role of disorder
7.4 Currents at the edge
7.5 Laughlin liquid

Text Books:

1. Philip Phillips – **Advanced Solid State Physics**, Cambridge university Press, 2nd ed. (2012), Cambridge

Reference Books:

1. Taylor Philip & Heinonen Olle – **Quantum approach to condensed matter physics**, Cambridge university Press, (2002).
2. Altland Alexander and Simons Ben – **Condensed matter field theory**; Cambridge university Press, south asian ed. (2008).
3. Wen Xiao-Gang – **Quantum field theory of many-body systems,** Oxford university Press, (2004).
4. Mahan Gerald – **Many-particle Physics**, 3rd edition, Springer (India), Pvt. Ltd., New Delhi (1990).