Special Topics in Condensed Matter Physics and Experimental Methods

Unit –I : Introduction

Crystal structure, symmetries, scattering, solids - crystalline, amorphous and liquid Crystals, Types of bonds- van der Waals, covalent, ionic and metallic bonding, Lattice vibrations, vibrations of mono and di-atomic lattices, Electrons in periodic potential, Bloch theorem, tight binding model.

Unit –II: Transport and Thermodynamic studies

Free electron models, heat capacity- Einstein and Debye models-electronic heat capacity Heat capacity of the electron Gas-Experimental heat capacity of metals-Electrical conductivity and ohms law, Resistivity-residual resistivity ratio-Experimental Electrical Resistivity of metals- Matthiessen's rule-Magnetoresistance- Giant magnetoresistance – CMR- Hall Effect

Unit- III : Magnetism

Magnetism- diamagnetism, paramagnetism of d and f electrons, Hund's rules, ferro and anti-ferromagnetism, Curie law-Weiss, Pauli paramagnetism, RKKY interaction and de Gennes scaling, *d* electron and Itinerant magnetism, Kondo effect, Single ion Kondo effect , Stoner theory, Crystalline Electric field (Schottky anomaly), Steven's equivalent operators, Heisenberg model, mean field theory, spin waves, spin glass.

Unit –IV: Superconductivity

Superconductivity- Meissner effect, London's equations, BCS model conventional- unconventional Metal-to-Insulator transition, Superconducting magnets- Heavy fermion compounds- Quantum critical phase transitions in heavy fermions , Anderson Model ,Ginzburg- Landau model, flux quantization, types of superconductors, vortex lattice- High Tc superconductors

Unit -V : Experimental methods

Crystal growth methods- Triarc furnace construction and working-Measurement techniques-X-ray diffraction- Laue pattern for crystal orientation, Single crystal diffractometer (four circle geometry) - neutron diffraction –electron diffraction- Magnetization measurements (SQUID VSM) magnetoresistivity and Hall measurements - Four probe resistivity measurement- Specific heat measurement- Mossbauer spectroscopy- E-beam Characterization- SEM –TEM -HRTEM-AFM

Referenc

1.Charles Kittel, Introduction to Solid State Physics, Wiley Eastern, 5th edition, 1983.
2. Helmut Kronmüller ,Stuart Parkin ,Handbook of Magnetism and Advanced Magnetic Materials,wiley (2007)
3. S. Lovesey, "Theory of neutron scattering from condensed matter", Oxford, 1984.
4. T.H.K. Barron and G.K. White, Heat capacity and thermal expansion at low temperatures Kluwer Academic/Plenum Publishers, New York 1999.
5. Laurent-Patrick Lévy. Magnetism and superconductivity , Springer, 2000.
6. Ashcroft & Mermin : Solid State Physics, Holt, Rinehart and Winston, 1976