

ICTP DIPLOMA PROGRAMME IN CONDENSED MATTER PHYSICS 2014-15

SYLLABUS

Electrons and Phonons in Solids - {24 Lectures = 36 hours}

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1. CRYSTAL STRUCTURES

Bravais Lattices
Wigner-Seitz Unit Cell
Lattices with a Basis
Close Packed Lattices

2. RECIPROCAL LATTICE

Plane Waves with Lattice Periodicity
Definition of Reciprocal Lattice
Brillouin Zone

3. ELECTRONIC STATES IN A CRYSTAL

Bloch Theorem
K-dependent Hamiltonian
Band Structure
Fermi Level and Fermi Surface
Density of States
Fermi-Dirac Distribution
Heat Capacity of Free Electrons

4. QUASI-FREE-ELECTRON MODEL

Free-Electron Bands in a Ghost Lattice
Splitting Degeneracies
Estimate of Splitting with Bare Ionic Potential
Thomas-Fermi screening

5. TIGHT-BINDING APPROXIMATION

Derivation of Secular Equation
Matrix Elements between s and p States
Examples including Graphene, fcc and bcc Lattices with s, p Orbitals

6. APPLICATION OF BAND THEORY

Optical Properties of Crystals

Vertical Transitions

Direct and Indirect Gap
Velocity of a Bloch State
Semiclassical Transport
Bloch Oscillations

7. BORN-OPPENHEIMER APPROXIMATION

Full Hamiltonian (Electrons + Ions)
Electronic Hamiltonian
Newton's Equation as Classical Limit & Ion Dynamics

8. PHONONS

Expansion of Total Energy

Force Constants and Dynamical Matrix

Normal Modes

Linear Monoatomic Chain

Linear Chain with Two Springs

Acoustic and Optical Modes