

MANY-BODY PHYSICS

**Syllabus**

Alexander A. Nersesyan

*The Abdus Salam International Centre for Theoretical Physics, Trieste,  
Italy*

**Master degree course**

Years: 2011-2012, 2012-2013

# 1 PHONONS

## 1. Lattice dynamics in one dimension

- Classical harmonic chain. Continuum limit and sound waves in elastic string
- Quantum approach: acoustic phonons
- Lattice with a basis: optical phonons

## 2. Lattice dynamics in three dimension

## 3. Thermodynamics: Debye model

## 4. Lattice stability; role of dimensionality

# 2 MAGNONS

## 1. Exchange Hamiltonian

## 2. Spin waves in ferromagnets

- Holstein-Primakoff transformation
- Equations of motion

## 3. Spin waves in antiferromagnets

## 4. Broken symmetry, Goldstone modes and quantum fluctuations

# 3 ELECTRONS

## 1. Free electrons

- Thermodynamics
- Particle-hole excitations in an ideal electron gas. Dynamical form-factor

## 2. Effects of Coulomb interaction

- Static screening and plasma oscillations
- Random Phase Approximation

## 3. Electrons on a lattice

- Tight-binding model. Band spectrum
- Bloch oscillations
- Electrons on a diatomic chain: ground state energy and charge density wave
- Types of band spectrum in two and three dimensions

# 4 ELECTRON-PHONON INTERACTION IN ONE-DIMENSIONAL SYSTEMS

## 1. Electron-phonon interaction

## 2. Peierls insulators

## 3. Soliton excitations

### Supplementary material:

1. Specific heat of ideal Fermi gas. Sommerfeld method
2. Mean-field approximation: Ising model
3. Linear response theory
4. Brief introduction to Green's functions and Feynman diagrams. RPA by diagrammatics