MANY-BODY PHYSICS

Syllabus

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Master degree course

Years: 2014-2015

1 PHONONS (3 lectures)

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. Debye model.**
3. **Lattice stability. Role of dimensionality**

2 MAGNONS (3 lectures)

1. **Spin waves in ferromagnets**
   - Holstein-Primakoff transformation
   - Equations of motion
2. **Spin waves in antiferromagnets**

3 ELECTRONS AND PHONONS (3 lectures)

1. **Electrons on a lattice**
   - Tight-binding model. Band spectrum
   - Electrons on a diatomic chain: ground state energy and charge density wave
2. **Electron-phonon interaction.**
   - Electron-phonon interaction
   - Peierls insulators. Soliton excitations

4 INTRODUCTION TO PHASE TRANSITIONS AND CRITICAL PHENOMENA (4 lectures)

1. **Overview**

   - First order and second order transitions. Spontaneous symmetry breaking and long-range order. Examples and basic models.
   - Goldstone theorem.

2. **Mean-field theory**

   - Mean-field theory of magnetic phase transitions.
   - Pair correlations and Ornstein-Zernike formula.
   - Validity of mean-field theory. Ginzburg criterion.
   - Mermin-Wagner theorem.

3. **Critical fluctuations. Ideas of scaling. Universality.**

4. **Exactly solvable models:**

   - One-dimensional Ising model.
   - Two-dimensional degenerate systems: topological phase transition in 2D XY model.