Università degli Studi di Cagliari
Facoltà di Scienze MM.FF.NN.
A.A. 2012/2013

Degree Program: Physics ("magistrale")

Course: Condensed-matter physics ("Struttura della materia")

Instructor: Vincenzo Fiorentini

Course contents

A. Solids: stability and ground state properties

Basics - Crystal lattices and symmetry (A c.4,5,6,7); cohesion of molecular and ionic solids (A c.19,20). Bloch theorem; energy bands (A c.8); "nearly-free electron" vs localized orbitals: plane waves vs tight binding (A c.9, 10). Density of states, critical points.

Interacting electrons - Drude and Sommerfeld electron gas. Drude-Lorentz dielectric response (A cap.1,2). Interacting electron gas at the Hartree-Fock level; correlation beyond HF according to Wigner and Thomas-Fermi (A c.17; P c.4,5). Cohesion of metals (P c.5, M c.11). Density-functional theory.

Lattice dynamics - Adiabatic approximation (P cap.2) and exceptions. Normal modes of vibration and acoustic-optical dispersion relations (A c.22). Quantization: phonons and boson statistics (A c.23).

B. Solids: response

Thermal and dielectric properties due to the lattice - Specific heat (A c.23), thermal expansion, fusion, stability in 1, 2, 3 spatial dimensions (A c.24; K c.4). Phonons in metals and electron-phonon interaction (A c.26). Dielectric response for phonons: longitudinal modes, polaritons (BG c.7.2).

Electronic dielectric response - Dielectric function and Kronig-Kramers relations. Longitudinal dielectric response: energy loss (G c.VII-7,8,9). Transverse dielectric response: optical constants, interband absorption (direct, indirect, dipole-allowed or forbidden). JDOS and critical points in 1, 2, 3D. Tauc relations (G c.XII-1.1,2,3).

Magnetism and phase transitions - Atom in magnetic field: diamagnetism; van Vleck and Curie paramagnetism (PM) (B c.2). Elementary Landau theory of phase transitions: symmetry breaking, order and disorder, rigidity, excitations, critical behavior (K c.2). Weiss theory of ferromagnetism (FM). Magnons and Bloch law (B c.5,6). FM vs antiFM coupling; basics of crystal field, quenching, Jahn-Teller, etc. (B c.4). Electron gas PM (Pauli) and FM (Stoner). Magnetic electron-gas oscillations in inhomogeneous magnetic field: RKKY interaction, spin waves, Kohn anomalies, and "apparent" antiFM (B c.7). Daring souls can also look at K c.6.

Textbooks

A = Ashcroft-Mermin, *Solid state physics*
B = Blundell, *Magnetism in condensed matter*
BG=Bassani-Grassano, *Fisica dello stato solido*
G = Grosso-Pastori, *Solid state physics*
K = Khomskii, *Basic Aspects of the Quantum Theory of Solids*
M = Marder, *Condensed matter physics*
P = Phillips, *Advanced solid state physics*
S = Singleton, *Band Theory And Electronic Properties Of Solids*

Course objectives

Learning the basics of solid state physics.

Prerequisites

Quantum mechanics. Atomic and molecular physics. Elements of statistical mechanics. Calculus and Fourier transforms.

Teaching techniques

Lectures and recitations (proportion 4 or 5:1). Practical session may be planned to demonstrate the actual calculation of properties of realistic systems with open source codes.

Final Examination

Oral examination.

Other information

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This document: http://www.dsf.unica.it/~fiore/sdm12eng.pdf