



UNIVERSITÀ DEGLI STUDI DI TRIESTE

Graduate Program in Physics/ February 2016/

Lectures on **TOPICS IN ADVANCED SPECTROSCOPY OF SOLIDS**

Prof. FULVIO PARMIGIANI - Department of Physics University of Trieste (Italy)

e-mail: fparmigiani@units.it

SCOPE OF THE LECTURES

The lectures are thought for graduate students in condensed matter. The aim is to provide a clear and possibly simple background of some advanced spectroscopies of solids suitable for observing low energy interactions in condensed matter. The program start with some basic classical concepts on the matter-radiation interaction leading to the description of the absorption and scattering processes, then expanded to the quantum-mechanical formalism. The last two sets of lectures will cover fundamental spectroscopic concepts applied to the study of some low energy magnetic interactions and elementary excitations in solids and as these interactions and excitations can be detected by X-ray Magnetic Circular Dichroism (XMCD), X-ray Magnetic Linear Dichroism (XMLD) and non-linear based spectroscopies, such as Raman and Resonant Inelastic X-ray scattering (RIXS).

1- Light-matter interaction: the classical picture

- 1.1 The physics of the Lorentz oscillators - free and forced.
- 1.2 - Properties of the Lorentz oscillators.
- 1.3 - The dielectric function, the refractive index and the optical conductivity.
- 1.4 - Drude Model. Extended Drude model and the sum rules.
- 1.5 - Scattering processes. Thomson scattering
- 1.6 - Elastic scattering from an atom, a molecule and a crystal.

2- Light-matter interaction: the quantum picture

- 2.1 - Electric dipole optical transitions.
- 2.2 - The matrix element and the selection rules.
- 2.3 - Quantum descriptions of the scattering processes.

3 - Light-matter interaction: some elementary excitations

- 3.1 - Interband absorption. Direct absorption.
- 3.2 - Excitons and excitons density
- 3.3 - Free excitons and bound excitons.
- 3.4 - Excitons in electric and magnetic fields.
- 3.5 - Spin of the excitons.
- 3.6 - Reststrahlung. Plasmons, Polarons and Magnons.

4 - X-ray absorption dichroism

- 4.1 - Basic physics of X-ray absorption
- 4.2 - X-ray magnetic Circular Dichroism beginning
- 4.3 - X-ray magnetic Linear Dichroism
- 4.4 - Sum Rules for Orbital and Spin Moments
- 4.5 - XMCD effects in the $L_{2,3}$ edges of TM
- 4.6 - XMCD effects in the M edges of Rare Earth (RE)
- 4.7 - XMCD effects in the L edges of RE
- 4.8 - Effects in the 4f5d exchange interaction.

4 - Non-linear spectroscopies

- 4.1 - The Rayleigh and Raman Scattering
- 4.2 - Kramers-Heisenberg formula
- 4.3 - Resonant Inelastic X-ray emission spectroscopy-
- 4.4 - Some basic theoretical aspects and experiments.