UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Optical Properties of Materials

2526-2-F1702Q012

Aims

The scope of the course is to provide a general theoretical picture to understand the optical properties of solids, their effects on the propagation of light in a material and how these properties need to be carefully considered when realizing optical systems.
The course will also extend the knowledge of a ray-tracing software (Zemax) to design and analyze simple optical systems taking into account the specific optical properties of different materials.

Learning Outcomes
Knowledge and understanding:
• Detailed knowledge of the basic concepts and approaches in optical properties of materials.

Applying knowledge and understanding:
• Acquisition of the ability to apply the theoretical notions covered in the course to the effective description of optical systems, also through the use of the Zemax software.

Communication skills:
• Aquisition of written and oral communication skilles on topics related to optical properties of materials.

Making judgements:
• The student will acquire the competence to judge which phenomena and observable of a given material can be ascribed to its intrinsic optical properties and how to apply them in practical cases.

Learning skills:
• The student can extend what he has learned in the lectures to case studies not covered during the course. In particular, he can independently manage the vast literature dedicated to the optical porperties of materials.

Contents

- Dielectric properties of solids and propagation of electromagnetic waves in a medium, accounting for anisotropy.
- Light polarization states and their applications.
- Main scattering mechanisms for electromagnetic waves.
- Introduction of nanostructuring effects on optical properties and optical metamaterials.
- Applications to simple cases relevant for optics and optometry using numerical simulations.

Detailed program

- Recall of structural and electronic properties of materials and their relations with optical properties. Distinction between crystals, amorphous and molecular materials, metals, semiconductors and insulators.
- Transmission and reflection of electromagnetic waves in an ideal macroscopic material. Recall of the Maxwell equations in vacuum and in matter, complex dielectric function, dielectric tensor.
- Characterization and measurement of light polarization states, applications to industrial measurements and photoelasticity.
- Optical anisotropy, dielectric tensor of anisotropic media, propagation of electromagnetic waves in anisotropic media, birefringence, retardation plates, dichroic polarizers.
- Overview of collective phenomena in solids relevant for optical properties: plasmons, excitons, polaritons.
- Scattering mechanisms of electromagnetic radiation: Rayleigh, Mie, Raman, Brillouin.
- Overview of optical properties of nanostructured materials.
- Introduction to optical metamaterials.
- Examples of applications of the aforementioned concepts in optics, optometry, ophthalmology with the support of simulations with the Zemax software.

Prerequisites

Classical electromagnetism and basic concepts of solid state physics.

Teaching form

-28 hours of frontal lectures using blackboard and/or slides, in-person with recordings of the lectures.
-14 hours of computational laboratory with Zemax, at distance.
The lectures will be given in English.

Textbook and teaching resource

Slides will be made available to the students through the present e-learning platform.

For further reading:

1. J. Peatross and M. Ware, Physics of Light and Optics (2015)
2. M. Fox, Optical Properties of Solids (Oxford University Press, 2010)

Semester

First semester

Assessment method

Oral exam.
Discussion concerning the topics covered during the course.
The ability to present the topics covered in class in all their conceptual and formal aspects will be assessed, including the derivation of the results.
No ongoing partial tests are planned.

Office hours

From Monday to Friday at any working hour (an appointment should be arranged with the teacher by email).

Sustainable Development Goals

QUALITY EDUCATION