Material-Radiation Interaction

In brief

Course langage: French

Presentation

Prerequisites

Quantum physics, electromagnetism basics

Learning objectives

To know the basic concepts and theory of the main physical phenomena involving the interaction of electrons and photon radiation in matter. To illustrate them in particular by the operation of lasers and their use to modify matter under high energy laser pulses. To observe these phenomena in living matter, which allow us to move from molecular imaging to medical diagnosis. To extend to the case of various radiations and particles (neutrons, X-rays...). To be able to make a presentation on a subject of one's choice in the field.

Description of the programme

1.Notions on lasers: Understanding lasers (The photon and the electron; absorption, stimulated and spontaneous emissions; optical pumping; black bodies). Illustration with laser materials in connection with atomic physics, and use of lasers in the rest of the course.

2. Laser-matter interaction: Introduction to the different categories of physical phenomena involved (photo-thermal, photo-ionization, photo-mechanics, etc.). Illustration by applications in industrial fields (additive or subtractive manufacturing, thermal treatments), or medical fields (skin treatments, ophthalmic surgery). Practical application through a numerical test carried out with Comsol, a multi-physics software (e.g. laser welding).

3. Introduction to bio-photonics: Applications of light-matter interactions to the study of complex systems: from cells to tissues. Study of fluorescence and coherent imaging to understand living organisms or make early diagnosis.

4. Atomic physics: Study of the interaction between electrons and photons in poly-electronic atoms under the effect of physical phenomena much finer than those seen in quantum physics. Probabilities of transitions between energy levels. Zeeman and Stark effects of external static fields. Illustration on rare earth ions used in laser amplifiers and fiber optic telecommunications, atomic clocks, magnetic resonance...

5. Notions on the interaction of matter with various particles: X-ray and neutron diffraction in relation with large facilities in Grenoble (ESRF and ILL)
- http://www.esrf.eu/
- http://www.giant-grenoble.org/fr/institut-laue-langevin-ill/

6. Listening to the presentations of other students: application topics of your choice validated by the teachers and extending the course.

Generic central skills and knowledge targeted in the discipline

This course gives the keys to really understand the interaction between matter and radiation (often used but only approached in other applications courses), allowing students to imagine and innovate beyond being simple users:
- Allows mobilization of an interdisciplinary culture between matter and radiation, quantum, microscopic and macroscopic.
- Understanding of the course exercising to understand and formulate complex problems by analyzing the different orders of magnitude of the concerned phenomena.
- Exercises the ability to quickly deepen a field while apprehending all its scientific and technical dimensions.
- In-depth presentation exercising the ability to produce a bibliographic research, stimulating the imagination.

How knowledge is tested

Continuous assessment to be specified among MCQs, lectures, homework, TP report (reform in progress).

Bibliography

Mécanique quantique par Claude Cohen Tanoudji et Coll Hermann 1977
Lasers et optique non linéaire
Christian Delsart Ellipses 2008, ISBN978-2-7298-3856-0 Centre Doc ECM 626.1
Fundamental of Photonics
BEA Saleh, MC Teich Wiley, 1991, ISBN 0-471-83965-5 Centre Doc ECM
Physique atomique B. Cagnac, JC Pebay-Peyroula, Dunod université 1975

Teaching team

Jean Bittebierre
Laurent Gallais, Nicolas Sandeau
intervenant extérieur de l'ESRF: Yves Joly

Sustainable Development Goal

Access to health

Total des heures		**30h**
CM	Master class	22h
TD	Directed work	4h
TP	Practical work	4h

Useful info

Name responsible for EU

Lead Instructor

Jean Bittebierre

jean.bittebierre@centrale-marseille.fr