Master Lumière, Matière, Interactions

	Light Waves In Complex Media: From Biological Tissues To Cold Atoms	Semester 2

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Course type	28h + exam CM 28h TD 4h	**3 ECTS**

Course Objectives

Light scattering in complex media prevents the use of standard imaging techniques such as conventional microscopy. Nevertheless, "seeing through scattering media" is a major challenge in various areas, such as biomedical imaging, soft matter, or the characterization of paints. Original approaches have been developed in the past twenty years, leading to novel protocols for the detection of objects and the imaging of turbid media in the multiple scattering regime.
The lecture introduces the basic physical concepts for the understanding of wave propagation in disordered scattering media, presents modern imaging techniques in these environments, and shows how to take advantage of the degrees of freedom of complex systems to achieve new functionalities.

Course prerequisites

General optics
Electromagnetism

Syllabus

Part I :LIGHT SCATTERING BY PARTICLES

- Wave equation, T-matrix, scattering cross-sections
- Optical theorem, dipole approximation, polarizability
- Particular cases (Rayleigh scattering, Mie scattering, large particles, two-level atoms)
- Examples: color due to scattering

Part II : MULTIPLE SCATTERING

- Ballistic and diffuse intensity, average field and fluctuations
- Cluster expansion, Dyson equation, Beer-Lambert law
- Bethe-Salpeter and radiative transfer
- Diffusion approximation, typical length scales
- Imaging modalities: Optical Coherence Tomography (OCT), diffuse tomography, inverse problems, acousto-optics
- Cold atoms: flash effect, radiation trapping

Part III : COHERENT EFFECTS

- Speckle statistics, memory effect and imaging
- Decoherence and multiple scattering, diffusing wave spectroscopy
- Coherent backscattering in disordered media (clouds, tissues, cold atomic gases)
- Introduction to weak and strong localization
- Matrix approach of wave propagation
- Time-reversal processing
- Beating imaging limitations with wavefront shaping techniques
- Disordered media as resources with new functionalities (super-lenses, spectrometers, …)

Bibliography

E. Akkermans and G. Montambaux, *Mesoscopic Physics of Electrons and Photons*, Cambridge University Press, 2006.

Assessment

Oral examination