UCLouvain

lphys2141

2026

Introduction to quantum optics

5.00 credits	22.5 h + 7.5 h	Q1

Teacher(s)	Génévriez Matthieu ;Urbain Xavier ;
Language :	English > French-friendly
Place of the course	Louvain-la-Neuve
Prerequisites	Having followed LPHYS1241, LPHYS1342 and LPHYS1344is an asset.
Main themes	Light-matter interactions, coherent population transfer, cold atoms, Bose-Einstein condensate, atomic clocks, NMR and MRI, scattering theory
Learning outcomes	**At the end of this learning unit, the student is able to :** **a. Contribution of the teaching unit to the learning outcomes of the programme (PHYS2M and PHYS2M1)** AA 1.1, AA 1.2, AA 1.5, AA1.6, AA 3.1, AA 3.3, AA 5.4 **b. Specific learning outcomes of the teaching unit** At the end of this teaching unit, the student will be able to: 1 1. describe the laser-atom interaction with Hamiltonian and density matrix formalisms ; 2. describe the essential steps leading to atom trapping, cooling and condensation ; 3. determine the experimental parameters for Doppler and sub-Doppler cooling ; 4. describe the essential steps leading to nuclear magnetic resonance imaging ; 5. give a quantum definition of scattering and master the concept of cross section.
Evaluation methods	Written examination, closed and open questions
Teaching methods	Lectures, video animations, numerical applications, exercises, laboratory demonstrations.
Content	Laser-atom interactions : two-state model – Rabi oscillations, adiabatic rapid passage, Bloch vector, Ramsey fringes, saturated absorption, and three-state model – optical pumping, two-photon spectroscopy, STIRAP, induced electromagnetic transparency, slow light. Cold atoms, atomic traps and Bose-Einstein condensates : Doppler and sub-Doppler cooling, magneto-optical and dipole trap, evaporative cooling, statistical mechanics of boson condensation, condensate properties, atom lasers. Applications of cold atoms to metrology : atomic clocks, atomic fountains, cold ions in Lamb-Dicke regime, quantum jumps, atomic qubits. Density matrix and Von Neumann-Liouville equation. Introduction to the principles of Nuclear Magnetic Resonance (NMR) and Magnetic Resonance Imaging (MRI) : magnetic Bloch equations, spin echoes, Fourier Transform NMR, basic MRI pulse sequences.
Bibliography	C. Foot (2005), « Atomic Physics », Oxford University Press, ISBN: 9780198506966 G. Grynberg, A. Aspect, C . Fabre, « Introduction to Quantum Optics », Cambridge University Press, 2010 C. Cohen –Tannoudji, Bernard Diu, Franck Laloë, « Mécanique quantique, tome III », CNRS Editions, EDP Sciences – Collection: Savoirs Actuels, 2017. M. Fox « Quantum Optics. An introduction », Oxford Master Series in Atomic, Optical, and Laser Physics, 2006. M. Fox « Optique quantique. Une introduction », trad. B. Piraux, De Boeck Université, 2011. P.Lambropoulos and D.Petrosyan « Fundamentals of Quantum Optics and Quantum Information », Springer, 2007. S. Haroche and J.-M. Raimond « Exploring the Quantum », Oxford, 2007. M.O. Scully & M.S. Zubairy « Quantum Optics », Cambridge University Press, 1997.
Faculty or entity in charge	PHYS

Programmes containing this learning unit (UE)				
Program title	Acronym	Credits	Prerequisite	Learning outcomes
Master [60] in Physics	PHYS2M1	5		🔍
Master [120] in Physical Engineering	FYAP2M	5		🔍
Master [120] in Physics	PHYS2M	5		🔍
Advanced Master in Nanotechnologies	NANO2MC	5		🔍
Master [120] of Education, Section 4 : Physics	PHYS2M4	5		🔍