UCLouvain

lphys2246 — Experimental methods in atomic and molecular physics

2023

5.00 credits	30.0 h	Q2

Teacher(s)	Lauzin Clément ;Urbain Xavier ;
Language :	English > French-friendly
Place of the course	Louvain-la-Neuve
Main themes	The main themes of this teaching unit are charge particle optics, atomic and electronic collisions, and atomic and molecular spectroscopy. We elaborate on the means to produce, store and guide charged particles using electric and magnetic fields. We illustrate the relevance of this know-how to the study of cross sections of collisions or photon-induced processes. An emphasis is then put on ultra-sensitive and precise techniques of spectroscopy using the detection of photons or of charged particles. Different cooling techniques, i.e. supersonic expansion and buffer gas cooling, are also presented to simplify and enhance quantized signatures in absorption or collision experiments.
Learning outcomes	**At the end of this learning unit, the student is able to :** 1 **a. Contribution of the teaching unit to the learning outcomes of the programme (PHYS2M and PHYS2M1)** AA 1.1, AA 1.2, AA1.3, AA1.4, AA 1.5, AA1.6, AA2.1, AA2.2, AA 3.1, AA 4.2, AA5.1, AA5.2, AA 5.3,AA 6.1, AA 7.2, AA 7.3, AA7.5, AA8.1, AA 8.2 **b. Specific learning outcomes of the teaching unit** At the end of this teaching unit, the student will be able to : 1. determine the most efficient experimental methodology to study a problem in atomic or molecular physics ; 2. know what are the limitations and advantages of various experimental techniques in atomic and molecular physics ; 3. identify the methods in use in scientific publications and evaluate their pertinence 4. put into equations the trajectory of charged particle beam and simulate it with appropriate software tools ; 5. identify and characterize the elements of a particle accelerator.
Evaluation methods	The evaluation will be based on an individual project and its oral presentation.
Teaching methods	Lectures, laboratories, practical project, commented laboratory tours.
Content	The teaching unit will adopt the following structure : 1) Charged particle optics • generation of charged particles: electron, positron, ion • basic principles of charged particle optics : general equations of motion, paraxial approximation and applications to electric and magnetic fields • concept of emittance: Liouville theorem and derivation of the beam envelope in phase space • practical training with real beams and simulation tools 2) Experimental approach of atomic and electronic collisions • velocity distributions : gas cell, effusive and supersonic beam • velocity selection : rotating slit, Doppler, fast beam • kinematics of beam-beam interaction : crossed beams, merged beams • form factor : the animated beam method • detection techniques : surface ionization, laser-induced fluorescence, electron multipliers, position sensitive detectors • analysis methods : translational spectroscopy, coincidence detection, 3D imaging • ion traps : Penning trap, Paul trap, quadrupole trap, electrostatic cavity • storage rings : electron-ion interaction, sympathetic and stochastic cooling 3) Molecular spectroscopy Absorption spectroscopy • frequency modulation

	• -principle of a lock-in amplifier • cavity enhanced and cavity ringdown spectroscopy • NICE-OHMS spectroscopy Action spectroscopy • photofragmentation spectroscopy • photoelectron spectroscopy • spectroscopy in an ion-trap The teaching unit will incorporate the latest experimental developments in atomic and molecular physics. Visits to a large European experimental facility will be organised.
Bibliography	H. Wollnik, Optics of Charged Particles (Academic Press, Orlando, 1987). High-resolution molecular spectroscopy, handbook, Wiley online library 2011.
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		🔍