UCLouvain

lfyki1302

2026

Nuclear physics and special relativity

5.00 credits	30.0 h + 22.5 h	Q2

Teacher(s)	Charlier Jean-Christophe ;Gonze Xavier ;
Language :	French
Place of the course	Louvain-la-Neuve
Prerequisites	This course assumes knowledge of : • The concepts of statistical/quantum physics and solid state physics as taught in course **LFYKI1102** (Statistical Physics and Solid State Physics I) or equivalent course.
Main themes	The course presents the fundamentals of nuclear physics and special relativity, as well as a supplement on quantum mechanics based primarily on its relativistic character. The topics covered include elements of nuclear physics that provide a basic understanding of radioactivity and nuclear energy management, the use of fundamental concepts inherent in special relativity to solve practical problems (GPS, satellites, ...), and finally, modifications to non-relativistic quantum mechanics due to special relativity, including spin-orbit interaction.
Learning outcomes	**At the end of this learning unit, the student is able to :** **Contribution of the course to the program's learning outcomes** With regard to the learning outcomes of the « Bachelor of Engineering Sciences within the Civil Engineering program », this course contributes to the development and acquisition of the following learning outcomes: • Axis 1 : knowledge of fundamental and polytechnic sciences: 1.1 • Axis No. 2 : 2.3, 2.6, 2.7 **Learning outcomes specific to the course** At the end of this course, students will be able to: • understand and integrate the concepts of nuclear stability, isotopes, and half-life (e.g., 14C dating); • differentiate between radioactive emissions from different types of nuclear decay; • calculate the nuclear energy emitted during nuclear fission or fusion reactions; • understand and integrate the non-intuitive concepts inherent in special relativity (length contraction – time dilation, slowing down of moving clocks, twin paradox, ...); • use the formulas of relativity theory to move from one Galilean reference frame to another and solve concrete problems (GPS, satellites, ...) ; • explain particle creation and annihilation in quantum mechanics ; • be able to describe the quantum dynamics of a relativistic particle ; • understand the concepts of spin and spin-orbit coupling in real materials.
Evaluation methods	Students are assessed individually **in writing** on the basis of the specific objectives announced in advance (questions testing their knowledge, understanding, and ability to apply the concepts covered in the course, the latter being developed during the practical sessions).
Teaching methods	Lectures and practical learning sessions (tutorials) run in parallel to enable students to apply the theoretical concepts presented in a more concrete way.
Content	**1. Nuclear physics** 1.1. Historical aspects of radioactivity 1.2. General properties of the nucleus (isotopes) 1.3. Nuclear models (valley of stability) 1.4. Weak interactions / strong interactions 1.5. Nuclear reactions 1.6. Alpha decay 1.7. Beta decay 1.8. Nuclear and atomic de-excitation (gamma radiation) 1.9. Fusion/fission 1.10. Nuclear energy **2. Relativity** 2.1. Inconsistency between Newtonian mechanics and Maxwell's theory 2.2. Lorentz transformations

	2.3. Nonlinear addition of velocities (from Galileo to Einstein) 2.4. Space-time 2.5. Relativistic kinematics 2.6. Concrete problems integrating the concepts of special relativity 2.7. General concepts of general relativity (gravitational field, black holes, gravitational waves, ...) **3. Elements of relativistic quantum mechanics** 3.1. Generalization of Schrödinger's equation for relativistic particles 3.2. Concept of spinors 3.3. Dirac equation (massive particle with spin ½) 3.4. Concept of spin-orbit coupling 3.5. Creation and annihilation operators 3.6. Applications to real materials
Bibliography	Plusieurs livres basés sur la thématique de la physique nucléaire et relativiste sont disponibles en bibliothèque.
Faculty or entity in charge	FYKI

Programmes containing this learning unit (UE)

Program title	Acronym	Credits	Prerequisite	Learning outcomes
Minor in Applied Chemistry and Physics	MINOFYKI	5		
Specialization track in Applied Chemistry and Physics	FILFYKI	5		
Mineure Polytechnique	MINPOLY	5		