SUBJECT TEACHING GUIDE

G58 - Quantum Physics and the Structure of Matter IV: Nuclei and Particles

Double Degree in Physics and Mathematics
Degree in Physics

Academic year 2021-2022

1. IDENTIFYING DATA					
Degree	Double Degree in Physics and Mathematics Degree in Physics			Type and Year	Compulsory. Year 3 Compulsory. Year 3
Faculty	Faculty of Sciences				
Discipline	Subject Area: Quantum Physics and the Structure of Matter Central Module				
Course unit title and code	G58 - Quantum Physics and the Structure of Matter IV: Nuclei and Particles				
Number of ECTS credits allocated	6	Term		Semester based (2)	
Web					
Language of instruction	Spanish	English Friendly	Yes	Mode of delivery	Face-to-face

Department	DPTO. FISICA MODERNA
Name of lecturer	ALICIA CALDERON TAZON
E-mail	alicia.calderon@unican.es
Office	IFCA - Edificio Juan Jordá. Planta: - 1. DESPACHO (S104)
Other lecturers	PABLO MARTINEZ RUIZ DEL ARBOL

3.1 LEARNING OUTCOMES

- Students must:
  - Acquire basic knowledge of the atomic nuclei structure, nuclear processes, elementary particles.
  - Acquire knowledge of the interaction of alpha, beta, high-energy electromagnetic radiation and hadrons, leptons and gauge bosons with the matter, and also about the corresponding detection methods and some important applications in the industry and medicine.
  - Acquire a basic understanding of the characteristics of weak and strong interactions (within the Standard Model), for example in what concerns the nucleon-nucleon potential.
  - Be able to calculate one-nucleon states with simple central potentials and approximate macroscopic nuclear properties.
  - Acquire a basic understanding of the characteristics of the ground and excited nuclear states, as well as of the nuclear decay mechanisms.
  - Understand the concept of cross section and the parameters that control a typical nuclear reaction or, more generally, between particles, paying attention to the conservation laws.
  - Acquire a basic understanding of the fission and fusion nuclear processes, as well as their most important applications.
  - Be able to interpret Feynman diagrams.

4. OBJECTIVES

To acquire basic knowledge of atomic nuclei, nuclear processes, elementary particles and their interactions (in the scheme of the Standard Model), as well as the effects of the passage of ionizing radiation (due to alphas, betas, gammas or hadrons) through the matter and the methods for detecting these radiations. It is also intended to give a basic idea of possible applications of the Nuclear Physics and ionizing radiation in the industry and medicine fields.

6. COURSE ORGANIZATION

	CONTENTS
1	Chapter 1. Basic Concepts. General Introduction to Nuclear and Particle Physics
2	Part II: Nuclear Physics Chapter 2. Nuclear Phenomenology 2.1 Mass spectroscopy and binding energy. 2.2 Nuclear shapes and sizes. 2.3 Stable and unstable nuclei. 2.4 Semi-empirical mass formula. Drop model. 2.5 Radioactive decay: general properties. 2.6 Alpha, beta and gamma decay. 2.8 Nuclear fission. 2.9 Nuclear reactions. Chapter 3. Nuclear Models 3.1 Nucleon-nucleon interaction. Nuclear potential. The deuteron. Independence of charge and symmetry of nuclear interaction. 3.2 Fermi gas model. 3.3 Layer model. Magnetic spin, parity and moment in the layered model. 3.4 Excited states in the layer model. 3.5 Non-spherical nuclei: collective model. Chapter 4. Nuclear Decay 4.1 General properties: decay constant, half-life and period. 4.2 Nuclear stability: alpha decay. 4.3 Beta decay. Fermi theory, electron moment distribution. 4.4 Gamma decay: selection rules, transitions. 4.5 Internal conversion.

3	Part III: Particle Physics Chapter 5. Introduction to particle physics and the Standard Model. 5.1 Matter - Antimatter 5.2 Symmetries and conservation laws. 5.3 Feynman diagrams Chapter 6. Leptons, Quarks, and Hadrons 6.1 Multiplets of leptons and lepton numbers 6.2 Neutrinos. Oscillations and masses 6.3 Evidence for quarks. Generations and quantum numbers 6.4 Hadrons: independence of flavor and charge multiplets 6.5 Spectroscopy of the quark model Chapter 7. Strong Interaction 7.1 Color Concept. QCD 7.2 Bound states of heavy quarks 7.3 Coupling constant of the strong force and asymptotic freedom 7.4 Jets and gluons 7.5 "Deep inelastic scattering" experiments Chapter 8. Weak Interaction 8.1 Neutral and loaded currents. W and Z. Symmetries of the weak interaction 8.2 Spin structure of weak interactions 8.3 Weak interaction in hadrons. 8.4 Unification of electromagnetic and weak interactions
4	Part IV: Radiation Matter Interaction, Nuclear Instrumentation Chapter 9. Interaction of Ionizing Radiation with Matter 9.1 Concepts of Range, Interaction Length, Attenuation. 9.2 Passage of Charged Particles in a Medium. Coulombian Interaction. Dispersion and Ionization 9.3 Bethe-Bloch formula. Projectile and Medium Dependence. 9.4 Brehmsstralumg. Radiation Length and Critical Energy 9.5 Cherenkov effect 9.6 Gamm Rays: Photoelectric Effect, Compton Scattering, Pair Production, Attenuation 9.7 Hadron Interaction 9.8 Waterfall Phenomena Chapter 10. Detectors and Instrumentation 10.1 Gas Detectors: Ionization Chamber, Proportional Counter, Geiger-Mueller Counter 10.2 Scintillation Counters and Photomultipliers 10.3 Solid State Counters 10.4 Accelerators. Detectors in colliders

7. ASSESSMENT METHODS AND CRITERIA

Description	Type	Final Eval.	Reassessn	%
Continuous assessment: throughout the course Continuous assessment will take place throughout the course, during class time. They will be carried out between 3 and 5 controls of the theoretical and practical contents of the last weeks.	Written exam	No	Yes	40,00
Final exam: all contents	Written exam	Yes	Yes	60,00
TOTAL				100,00

Observations

To pass the course, students must satisfy the specified requirements, for continuous and final evaluation, specified in the previous sections.

If the development of the classes in person were not possible, videoconferences would be used to carry out this activity. If it is not possible to carry out the exams in person, the Moodle application of the Virtual Classroom for this.

Observations for part-time students

Part-time students will receive facilities so that they can follow the course.

8. BIBLIOGRAPHY AND TEACHING MATERIALS

BASIC

B. R. Martin: Nuclear and Particle Physics, segunda edición, Ed. John Wiley, NY 2009 (Parte IV)