Bachelor in Physics
(Academic Year 2025-26)

Structure of Matter			**Code**	800516	**Year**	3rd	**Sem.**	2nd
Module	General Core	**Topic**	Quantum physics and statistics		**Character**		Obligatory	

	Total	Theory	Exercises
ECTS Credits	6	3.5	2.5
Semester hours	55	30	25

Learning Objectives (according to the Degree's Verification Document)

- To learn the structure of poly-electronic atoms and their basic modeling.
- To comprehend the Born-Oppenheimer approach and the electronic structure of diatomic molecules and other compounds.
- To obtain a first insight of the smallest constituents of matter, their interactions and the basic elements of the models involved, as well as the order of the physical magnitudes taking place in the processes among elementary particles.
- To understand the basic nuclear phenomenology and some simple models.

Brief description of contents

Introduction to poly-electronic atoms; foundations of molecular structure and bonding; basic properties of atomic nuclei; introduction to particle physics and its phenomenology.

Prerequisites

Wave function and Schrödinger equation. Simple quantum systems and their spectra (harmonic oscillator, central potentials, the Hydrogen atom). Basics of symmetries and angular momenta. Quantum transitions and collisions.

Some approximate calculation methods in quantum systems: variational method, perturbations, etc.

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Theory/ Exercises – Schedule and Teaching Staff

Group	Lecture Room	Day	Time	Professor	Period/ Dates	Hours	T/E	Dept.
B	8 9	We Fr	12:00-14:00	Juan Abel Barrio Uña	Full term	55	T/E	EMFTEL

T: Theory, E: Exercises

Office hours				
Group	**Professor**	**Schedule**	**E-mail**	**Location**
B	Juan Abel Barrio Uña	Tu: 11:00-13:00 We: 14:00-16:00 Th: 15:00-17:00	barrio@gae.ucm.es	03.221.0

Syllabus

1. Atomic Physics

Review and extension of the hydrogenoid atom. Introduction to poly-electronic atoms. Central field approximation. Ground states and periodic table. Couplings of angular momenta of electrons. Atomic spectra.

2. Molecular Physics

Types of atomic bonds. Valence bond and molecular orbital theory in the hydrogen molecule. Born-Oppenheimer approximation. Rotational, vibrational and electronic spectra in diatomic molecules.

3. Particle physics:

Classification of elementary particles (quarks, leptons, gauge bosons) and fundamental interactions. Composite particles (hadrons), quark model. Masses, quantum numbers, conservation laws. Particle decays, production and detection. The nucleon, isospin.

4. Nuclear physics:

Nucleus composition. Nuclear masses and sizes. Stability. Nuclear structure models. Nuclear decay and radioactivity. Reactions, fission and nuclear fusion.

Bibliography

Basic bibliography:

• Quantum Physics of Atoms, Molecules, Solids, Nuclei, and Particles, Robert Eisberg and Robert Resnick, Wiley (1985).

• Fundamental University Physics: Quantum and Statistical Physics Volume III, Marcelo Alonso and Edward J. Finn, Addison Wesley (1976).

• Introduction to the Structure of Matter: A Course in Modern Physics, John J. Brehm y William J. Mullin, Wiley (1989).

Bibliography for specific areas:

• Physics of atoms and molecules, B.H.Bransden, C.J.Joachain. Longman (1994).

• Molecular Quantum Mechanics, P. W. Atkins. Oxford University Press (1989).

• Atomic structure, G.K.Woodgate. McGraw Hill (1980).

• Nuclear and Particle Physics, W.S.C.Williams. Oxford Science Publications (1991).

• Introductory Nuclear Physics, Kenneth S. Krane. Wiley (1987).

• Quarks and Leptons: An Introductory Course in Modern Particle Physics, Francis Halzen y Alan D.

Martin, Wiley (1984).

• Introduction to High Energy Physics, Donald H. Perkins. Cambridge University Press (2000).

Online Resources
UCM Virtual Campus

Methodology
The following training activities will be carried out: -Theory lectures (using blackboard and beamer) where the main concepts of the subject will be explained, including examples and applications. The corresponding slides will be uploaded in the Virtual Campus in advance - Exercise solving lectures (using blackboard). The corresponding exercise sheets will be uploaded in the Virtual Campus in advance

Evaluation Criteria		
Exams	**Weight:**	80%
The final exam will consist of a set of questions and/or problems.		
Other Activities	**Weight:**	20%
Other assessment activities will consist of mid-term exams, problems solving or short essays.		
Final Mark		
The final mark for the course (CF) will be obtained from the final exam (EF) mark and the marks for the other assessment activities (OAE), all between 0 and 10 points, as follows: - If the OAE mark is equal to or greater than 3.5 points, the final mark will be the highest of the EF mark and the weighted average: CF = MAX(EF, 0.8 * EF + 0.2 * OAE). - If the OAE mark is less than 3.5 points, the final mark will be the weighted average: CF = 0.8 * EF + 0.2 * OAE. The same procedure will be followed for both Ordinary and Extraordinary marks.		