Bachelor in Physics
(Academic Year 2021-22)

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	54	29	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**	Mon, Wed	15:00-17:00 14:30-16:30	Juan Abel Barrio	Full term	54	T/E	EMFTEL

T: Theory, E: Exercises

Office hours

Group	Professor	Schedule	E-mail	Location
B	Juan Abel Barrio	*Monday, from 17:00 to 18:30;* *Wednesday, from 16:30 to 18:00*	barrio@gae.ucm.es	Room 221, 3rd floor

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
On-campus teaching 100% (Scenario 0)
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
Semi-online teaching (Scenario 1)
Face-to-face lectures to a subgroup of students, which will be broadcast live to the rest through Microsoft Teams, Google Meet, or a similar application, making use of the technical infrastructure available.
Online teaching (Scenario 2)
Streaming lectures where the key aspects of the subject will be presented via Microsoft Teams, Google Meet or a similar application. The rest of streaming sessions will be devoted to review and correct exercise sheets.

Evaluation Criteria		
Exams	**Weight:**	70%
The exam will consist of a series of questions and/or problems		
Other Activities	**Weight:**	30%
- Review of exercise sheets (0-30%). - Mid-term short exam (0-30%).		
Final Mark		
The final grade will be formed as 0.7*E + 0.3*A, where E is the mark in the final Exam (on a 0-10 scale) and A is the mark in the Other activities (on a 0-10 scale). The final mark will be obtained following the same evaluation procedure in the ordinary and extraordinary calls.		