

Quantum Physics

Syllabus (2018/19)

* Course Description

1. Thermal Radiation and Photons [10 hr] JJ

- 1.1 Blackbodies. Wien's and Stephan's Laws.
- 1.2 Planck's Law.
- 1.3 Applications. Radiometry. Cosmic Microwave Background and the Big Bang.
- 1.4 Photons. Photoelectric and Compton effects. Diffraction.
- 1.5 X-Ray Radiation. Bremsstrahlung.
- 1.6 Pair Production and Annihilation.
- 1.7 Photon Absorption and Scattering. Cross sections.

2. Quantization and Early Atomic Models [8 hr] ML

- 2.1 Wave-Particle Duality and Properties of Matter Waves.
- 2.2 Uncertainty Principle. Einstein's and Bohr's Interpretations. Wave Functions.
- 2.3 Models of the Atom and Limitations: Thomson, Rutherford, Bohr, Sommerfeld.
- 2.4 Quantization of Physical Systems. Atomic Spectra. Wilson-Sommerfeld Rules. Correspondence principle.

3. Schrödinger's Theory of Quantum Mechanics [15 hr] JJ

- 3.1 Schrödinger's Equation.
- 3.2 Born's Interpretation of Wave Functions. Expectation Values.
- 3.3 Time-independent Schrödinger's Equation. Eigenfunctions.
- 3.4 Energy Quantization
- 3.5 Solution to the Time-independent Schrödinger's Equation: Zero and Step Potentials. Barrier Potential and Penetration. Square and Infinite Wells. Simple Harmonic Oscillator Potential.

4. One-electron Atoms [15 hr] ML

- 4.1 Development and solution of the Schrödinger Equation
- 4.2 Interpretation of Results Through Probability Densities
- 4.3 Spin and Orbital Angular Momentum
- 4.4 Spin-orbit Interaction and the Energy Levels of Hydrogen
- 4.5 Transition Rates and Selection Rules

5. Overview on elementary Particles [3 hr] JJ

- 5.1 Indistinguishability. Pauli's Exclusion Principle.
- 5.2 Distribution Functions: Boltzmann, Fermi and Bose.
- 5.3 Applications. Liquid Helium. The Laser. White Dwarf Stars.
- 5.4 The Zoo of Elementary Particles. Fermions and Bosons. Quarks.

6. Multielectron Atoms [5 hr] ML

- 6.1 Exchange Forces and the Helium Atom.
- 6.2 The Hartree Theory. Results of the Hartree Theory.
- 6.3 Ground States of Multielectron Atoms and the Periodic Table.
- 6.4. X-ray Line Spectra.

* Textbooks

MAIN:

- **Quantum Physics of Atoms, Molecules, Solids, Nuclei, and Particles:** R. Eisberg, R. Resnick. 2nd Ed. (1985) Wiley.

ALTERNATIVE:

- **Introduction to Quantum Mechanics:** D.J. Griffiths, 2nd Ed. (2004), B. Cummings

COMPLEMENTARY:

- **The Feynman Lectures on Physics, Vol. III Quantum Mechanics [Chapter 1]:**

R.P. Feynman, R.B. Leighton, M. Sands, 2nd Ed. (2005), Addison-Wesley

- **The Dreams that Stuff is Made of: the Most Outstanding Papers of Quantum Physics,** ed. S. Hawking (2011), Running Press

* Exams and Grading Policy

The Written Assignment is MANDATORY. The grade includes contributions from a Mid-term Exam (ME), a Final Exam (FE) and a Written Assignment (WA) and is obtained as:

$$\text{MAX}[0.65*FE+0.20*ME+0.15*WA, 0.85*FE+0.15*WA]$$

For re-evaluation, only the Final Exam will be taken into account.

* Instructors

Jordi José (DFIS), **Manuel Linares** (DFIS)

jordi.jose@upc.edu , manuel.linares@upc.edu