FONDAMENTI DI FISICA MODERNA

FIS/01 - 6 CFU - 2° Semester

Teaching Staff

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LEARNING OBJECTIVES

The aim of this course is twofold. On the one hand it serves as a completion that a deepening of already studied electromagnetism highlighting, in particular, its connection with special relativity. On the other hand, provides an overview of other fields of modern physics. In particular, in the first two parts of the program covers the fundamentals of special relativity, the covariant formulation of classical electromagnetism and the theory of radiation. The third part discusses some phenomena that have historically led to the formulation of quantum mechanics and its application in the field of atomic physics, nuclear and subnuclear physics.

The approach to the description of the phenomena covered by the course will be of an experimental and / or phenomenological type and the physical theories will be presented in terms of logical, mathematical and experimental evidence.

At the end of the course, the student will have acquired inductive and deductive reasoning skills, will be able to schematize a phenomenon in terms of physical quantities, will be able to critically deal with the studied subjects, set a problem and solve it with analytical methods, taking care of them, with due rigor, both mathematical and physical aspects. The student will apply the scientific method to the study of natural phenomena and will be able to critically evaluate analogies and differences between physical systems and the methodologies to be used. Furthermore, he will be able to expose the arguments of modern physics object of the course with language properties, focusing on the inductive / deductive process that allows us to reach conclusions from the starting hypotheses.

COURSE STRUCTURE

lectures accompanied by exercises

DETAILED COURSE CONTENT

Fundamentals of theory of special relativity and general relativity

Operational definition of measures of space and time – Conventionality of synchronization method: topological simultaneity and simultaneity metric - Einstein and Reichenbach synchronizations – Transformations of synchrony and its properties (*) - Postulates of special relativit - Time dilation, length contraction and Lorentz transformations – Algebraic-geometric properties of Lorentz transformations - Space-time Interval – Minkowski cronotopo – Temporal order and spatial separation of events - Proper time – The twin paradoxs - Lorentz transformations - Transformations of speed and acceleration vectors – Proper acceleration – Transformations of momentum, energy and strength - Aberration and Doppler effect – Reflection by an in motion mirror - Elements of general relativity theory: the equivalence principle, deflection of light in a gravitational field, gravitational red shift, black holes.

Classical theory of radiation and covariant formulation of Maxwell's equations

References on Maxwell's equations - The conservation laws: Poynting vector and the Maxwell stress tensor – Helmoltz decomposition theorem (*) - Plane waves in Ohmic conductors (*) - Potential of c.e.m. and gauge transformations – Method of Green's function for the solution of the wave equation – Retarded potentials – Liénard-Wiechert potentials and electromagnetic field generated by a charge in motion : radiation from accelerated charge at low speed and Larmor formula - Stability of hydrogen-like atom – Bremsstrahlung – Synchrotron radiation – Cherenkov radiation - Liénard formula - Lorentz transformations as rotations in the Minkowski spacetime – Space-time, velocity and acceleration four-vectos – Current density and potential four vectors - Electromagnetic field tensor - Electromagnetic field transformations - Maxwell equations in covariant form - Elements of calculus of variations – Remarkable lemmas of the calculus of variations - Special cases of the Euler-Lagrange equation – Relativistic Lagrangian Formulation of Lagrangian mechanics – Brachistochrone- Lagrangian and Hamiltonian of a charged relativistic particle in motion into an external c.e.m. - Minkowski force - Moton of charges in electric and magnetic fields uniforms – Inelastic processes thresholds (*) - Lagrangian formulation for continuous systems and fields - Lagrangian density of the electromagnetic field.

Elements of atomic physics, nuclear and subnuclear physics

The black body radiation and Planck's hypothesis - Photoelectric effect - Compton effect – Creation of pairs e+-e- - Thomson, Rutherford and Bohr atomic models - Size and constitution of the atomic nucleus – Density of nuclear matter – Nuclear forces, mass defect and binding energy per nucleon - Nuclear fission and fusion – γ β α activity, and unstable nuclei: radioactive decay law – Decay chains – Radioactive dating methods and use of radioactive isotopes as tracers – Electron diffraction - Indetermination Heisenberg principle – Elements of quantum mechanics: Schrodinger equation – Ehrenfest Theorem - Particle in a potential well – Tunneling – Harmonic oscillator - Yukawa theory of nuclear interactions – The four forces of nature – Quark – Grand Unified Theories.

Note: the arguments marked with an asterisk are optional.

TEXTBOOK INFORMATION

R. Resnick : Introduzione alla relatività ristretta" - C.E.A., Milano.

V. Barone Relatività - Bollati Boringhieri

H. Goldstein : Meccanica classica - Zanichelli

L. Lovitch, S. Rosati : Fisica Generale: Elettricità,Magnetismo, Elettromagnetismo,

Relatività ristretta, Ottica, Meccanica quantistica - C.E.A.

J.D. Jackson : Elettrodinamica classica - Zanichelli

A. Campolattaro : I fondamenti della fisica moderna, Liguori

P.A. Tipler, G. Mosca : Corso di Fisica – Fisica Moderna, Zanichelli

The student is free to choose any other text at the University level.