UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Nuclear and Subnuclear Physics - A-L

2627-3-E3001Q048-T1

Aims

We provide a modern introduction to nuclear and elementary particle physics based on special relativity and non relativistic quantum mechanics

Contents

Nuclear models and nuclear structure.
Radioactive decay law.
Radioactive decay types and environmental radioactivity.
Introduction of nuclear reactions: fission and fusion reactions.
Introduction to sub nuclear physics.
Elementary particles production: cosmic rays and particles accelerators.
Radiation interaction with matter and particles detectors.
Introduction to elementary particles physics.
Symmetries and conservation laws.
Hadronic resonances and quarks models.
Introduction to quantum electrodynamics.
Weak interactions.
Hadrons' Structure

Detailed program

Nuclear models and nuclear structure.

- Rutherford's experiment
- Nuclear data table and nuclear drop model: Von Weizsäcker - Williams law
- Nuclear shell model

Radioactive decay law.

- General definition of radioactive law.
- Definition of activity and their measurement unit.
- Application to multiple decays and radioactive chains.

Radioactive decay types and environmental radioactivity.

- Alpha decay
- Beta decay
- Gamma decay

Introduction of nuclear reactions: fission and fusion reactions.

- Nuclear reaction general scheme
- Nuclear fission processes
- Nuclear fusion processes

Introduction to sub nuclear physics.

- Elementary particles
- Classification of elememtary particles: hadrons, barions, mesons, leptons.
- Description of the interaction processes

Elementary particles production: cosmic rays and particles accelerators.

- Primary and secondary cosmic rays
- Hadronic interactions and cosmic rays shower productions
- Particles accelerator techinques

Radiation interaction with matter and particles detectors.

- Interaction of charged particles: Bethe Block law
- Photon interaction: photoelectric effect, Compton scattering, pair productions
- Characteristics of particles radiation detectors

Introduction to elementary particles physics.

- Pions, kaons and strange particles: classification of elementary particles
- Leptonic flavors: electronic, muonic and tauonic
- Elements of Special Relativity

Symmetries and conservation laws.

- Symmetry laws and symmetry breaking
- Definition of parity and charge coniugation
- Time reversal and CPT theoreme
- Conservation of quantum numbers

Hadrons and the Quark Model.

- Isospin Symmetry
- Resonances and the Breit-Wigner formula
- Hadronic resonances characterization
- Introduction to the Quark Qodel
- Barions and mesons descroption
- Colour

Introduction to quantum electrodynamics.

- Charge conservation and gauge symmetries
- The Lamb shift and the (g-2) determination
- Introduction to quantum field theory

Weak interactions.

- Classification of weak interactions
- Low energy leptonic processes and the Fermi costant
- Parity and charge coniugation violation in the weak interactions
- Helicity of leptons and the Goldhaber experiment
- The V-A theory and Chirality
- The K0 system and CP violation

Hadrons' Structure

- Deep Inelastic Scattering
- Asymptotic Freedom
- Constituent Quarks
-

Prerequisites

Basic knowledge of the three-year degree in physics and in particular non relativistic quantum mechanics and special relativity

Teaching form

Lectures.
Some possible seminars on specific arguments will be organized as parts of the course program.

The lessons held during the course will be saved and can be viewed on the elearning site in asynchronous mode. Possible seminars will be organized remotely with the support of a videoconference remote connection.

Textbook and teaching resource

A. Bettini, Introduction to Elementary Particle Physics, Cambridge University Press, 2014 (2nd edition)

G. Krane, Introductory Nuclear Physics, Wiley, 1988 (3rd edition)

F. Terranova, A Modern Primer in Particle and Nuclear Physics, Oxford University Press, 2021

Donald H. Perkins, Introduction to High Energy Physics, 4th edition, Cambridge University Press, 2000

During the course some bibliographic references will be indicated and some lecture notes will be available

Semester

Second semester

Assessment method

Oral examination - No intermediate evaluation will be organized

- Discussion on argument presented during the course
- Analysis on some aspects concerning nuclear and subnuclear physics
- Simple exercises on arguments discussed during the examination

Office hours

Monday - Friday by appointment

Sustainable Development Goals

QUALITY EDUCATION