UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Nuclear and Subnuclear Physics - Turno 1

2223-3-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.
Introduction to weak interactions.

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
- Dirac equation and its applications

Symmetries and conservation laws.

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

Hadronic resonances and quarks models.

- Breit–Wigner law

- Hadronic resonances characterization
- Introduction to the quark model
- Barions and meson descroption
- Color charge: a new quantum number

Introduction to quantum electrodynamics.

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

Introduction to 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

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.

During the COVID-19 emergency period the course will be delivered remotely with asincronous registered lessons. In any case, videoconference meetings will be periodically organized and, if it will be possible, some meetings in presence will be held.
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

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