



UNIVERSITÀ  
DEGLI STUDI DI MILANO-BICOCCA

## SYLLABUS DEL CORSO

### Fisica Nucleare e Subnucleare - Turno 1

2324-3-E3001Q048-T1

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#### 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 elementary 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 techniques

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 conjugation
- Time reversal and CPT theorems
- Conservation of quantum numbers

Hadrons and the Quark Model.

- Isospin Symmetry
- Resonances and the Breit-Wigner formula
- Hadronic resonances characterization
- Introduction to the Quark Model
- Barions and mesons description
- 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 constant
- Parity and charge conjugation 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
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## 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 asynchronous 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

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

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