UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Particle Physics III

2526-1-F1703Q034

Aims

Provide a wide overview of flavour physics phenomenology in both the hadronic and leptonic sectors. Insight in the experimental aspects (connection between experimental measurements and theory) and searches for physics beyond the Standard Model

Contents

Part A)

First observation of heavy quarks. Quarkonium. Production of heavy quarks at different accelerators. Decays and lifetimes of heavy hadrons. The Flavour Structure in the Standard Model. Flavour transitions: the CKM matrix and the measurements of its elements. Oscillations of neutral mesons (K, D, Bd, Bs), measurement of the oscillation parameters. The violation of the CP symmetry(CPV). Measurements of CPV in the B systems. Time reversal symmetry. Measurement of rare decays and search for New Physics in flavour transitions. Examples of measurements at e+e-colliders and at hadronic colliders.

Part B)

The discovery of neutrino oscillations as the first clear indication of physics beyond the Standard Model. Properties of massive neutrinos and experimental approaches to their study: mass, mixing, and lepton number conservation or violation. Neutrinos and Dark Matter in Astrophysics and Cosmology

Detailed program

Part A)

First observations of heavy quarks. Production of heavy quarks at different accelerators. Bound states, quarkonia, spectroscopy of heavy hadrons. Decays and lifetimes of heavy hadrons. The flavour structure in the Standard Model. Flavour transitions: the CKM matrix and the Unitarity Triangles. Measurements of CKM elements. Oscillations of neutral mesons (K, D, Bd, Bs), measurement of the oscillation parameters. The violation of the CP symmetry (CPV). Measurements of CPV in the B systems: CPV in mixing and in decay. Measurements of the UT angles. Time reversal symmetry. Measurement of rare decays and search for New Physics in flavour transitions. Search for charged lepton flavour violations.

Exemples of measurements performed by experiments at e+e- colliders at Y(4S), at Z? and at hadron colliders.

Part B)

1. Introduction: Astroparticle physics and neutrino physics.
2. Properties of massive neutrinos: Majorana and Dirac neutrinos.
3. Neutrino mass and mass-related observables.
4. Neutrino oscillations: Phenomenological modeling and experimental studies; interaction channels used for detection; two- and three-flavor oscillations; oscillations in vacuum and in matter. Discussion of selected key experiments.
5. Future prospects in oscillation measurements: Mass hierarchy and CP violation. Investigation of anomalies (sterile neutrinos).
6. Brief overview of cosmology in relation to neutrino mass and the matter-antimatter asymmetry. Introduction to the dark matter problem.

Prerequisites

Basic knowledge of quantum mechanics and basics of particle physics (eg from the course of Particle Physics 1)

Teaching form

Frontal lectures.

Textbook and teaching resource

Slides with lectures' notes and recording available on the e-learning platform.

Mark Thomson, "MODERN PARTICLE PHYSICS", Cambridge University Press, 2013.
A. Bettini, “Introduction to Elementary Particles Physics”, Cambridge University Press; D. Griffiths, “Introduction to Elementary Particles”, 2nd ed. Wiley;
M. Sozzi, "Discrete Symmetries and CP Violation, from experiment to theory" Oxford University Press;
A. Marrone Lecture Notes: Neutrino Physics and Astrophysics Marrone_GGI_2023.pdf
Samoil Bilenky Introduction to the Physics of Massive and Mixed Neutrinos ed. Springer
A. Strumia e F. Vissani Neutrino masses and mixings and... https://arxiv.org/pdf/hep-ph/0606054.pdf
C. Giunti and C.W. Kim Fundamentals of Neutrino Physics and Astrophysics Oxford university Press

Semester

Second semester

Assessment method

Oral examination about the content of the lectures. The questions will focus on both the topics covered in part A and part B. The evaluation will be based on the level of knowledge and understanding of the topic, and on the clarity and correctness of their presentation.

Office hours

By appointment via email

Sustainable Development Goals

QUALITY EDUCATION