Course syllabus

Partikelfysik, kosmologi och acceleratorer
Particle Physics, Cosmology and Accelerators

EXTF85, 7,5 credits, G2 (First Cycle)

Valid for: 2023/24
Faculty: Faculty of Engineering, LTH
Decided by: PLED N
Date of Decision: 2023-04-17

General Information

Elective for: F4, F4-axn
Language of instruction: The course will be given in English on demand

Aim

The aim of the course is to provide a general description of the fundamental discoveries in particle physics in the recent decades which have led to today's picture of the structure of matter, based on subnuclear constituents. An introduction to the quantum field theories, which were developed in order to describe the interactions between the building blocks, is given. Furthermore, the basic concepts in accelerator technology and the experimental techniques used in today's electronic detectors will be reviewed. Included in the course is also a laboratory exercise designed to measure the lifetime of cosmic muons.

Learning outcomes

Knowledge and understanding
For a passing grade the student must

- Describe how matter is built of quarks and leptons in the Standard Model
- Describe the fundamental interactions in the Standard Model
- Describe the basic observations that led to the Standard Model
- Discuss the predicted phenomena beyond the Standard Model
- Be familiar with the current research frontier in high energy physics

- Describe the evolution of the universe from the perspective of particle physics
- Describe the impact on the particle level of astrophysical observations
- Account for different particle interaction with matter, especially detectors
- Describe how to identify particles and determine their momentum.
- Account for the secondary beams of neutrons, muons, pions, and photons, for instance at the ESS and MAX facilities.
- Be familiar with accelerator use for materials studies and medical applications

Competences and skills
For a passing grade the student must

- Illustrate fundamental interactions and decays using Feynman diagrams
- Make quantitative estimates of reactions with the use of relativistic kinematics
- Using the method of four momentum for quantitative kinematic calculations
- Apply conservation laws to reactions
- Connect electronic devices for detection of muons from cosmic rays and measuring the time to decay.
- Using MATLAB determine muon lifetime from the measured results and generalize lifetime measurements on time scales of weak decays.
- Calculate the motion of charged particles in electric and magnetic fields

Judgement and approach
For a passing grade the student must

- Judge the natural science picture of the structure of matter based on experiments, modeling and theory.
- Judge the scientific picture of the structure of the universe and development based on observations, modeling and theory

Contents

The course consists of two elements, particle physics and cosmology, 6 points (hp), and accelerators and their uses, 1.5hp.

The student is given an overview of elementary particles and their interactions. Leptons, quarks and composite particles are discussed, and the electromagnetic, weak and strong force and its mediators. Reactions and decay represented by Feynman diagrams. Introduction of particle physics standard model with the electroweak interactions and quantum chromodynamics. The Higgs mechanism is introduced and possible theories beyond the Standard Model are discussed together with an orientation of the research frontier in high energy physics. In addition the cosmology related to particle physics, and some of the most important open questions such as dark matter, are discussed.
Methods to determine identity and momentum of particles are reviewed and the principles of high energy physics experiments. Experimental studies of subatomic systems require particle beams with high energy. Particle accelerators are used now also in the wider community, such as for medical applications and materials studies in physics, pharmacology, biology, chemistry, etc. The principles of acceleration, mainly synchrotron and linear accelerator, and storage of particle beams are reviewed. Examples are taken from the subatomic physics front line, the Large Hadron Collider at CERN, as well as studies relevant MAX and ESS in Lund. For these latter it is also studied how secondary beams of photons and neutrons are created for use for various applications

Examination details

Grading scale: TH - (U,3,4,5) - (Fail, Three, Four, Five)
Assessment: Satisfactory grades on the home exercises, the laboratory exercise, oral examination and compulsory study visit/compulsory paper.

The examiner, in consultation with Disability Support Services, may deviate from the regular form of examination in order to provide a permanently disabled student with a form of examination equivalent to that of a student without a disability.

Admission

Assumed prior knowledge: FAFF10 Atomic and Nuclear Physics with Applications.
The number of participants is limited to: No
The course overlaps following course/s: EXTF05, FKF050

Reading list

- Martin, B.R. & Shaw, G.: Particle Physics, John Wiley & Sons, 3rd edition.
- Supplementary lecture notes will be distributed by the institute.
- Complementary literature:.
- Williams, W.S.C.: Nuclear and Particle Physics, Oxford Science Publications.

Contact and other information

Course coordinator: Alice Ohlson, alice.ohlson@hep.lu.se
Course homepage: https://www.fysik.lu.se/index.php?id=108305
Further information: The course is given by the Faculty of Science and does not follow the study period structure.