SH2204 Astroparticle Physics 7.5 credits

Astropartikelfysik

This is a translation of the Swedish, legally binding, course syllabus.

Establishment

Course syllabus for SH2204 valid from Autumn 2011

Grading scale

A, B, C, D, E, FX, F

Education cycle

Second cycle

Main field of study

Physics

Specific prerequisites

Subatomic physics (SH2103), or equivalent.

Language of instruction

The language of instruction is specified in the course offering information in the course catalogue.

Intended learning outcomes

After completing this course, students should be able to:

- Classify the fundamental subatomic particles by their possible interactions.
- Explain how 'particle probes' can open a new window on the universe compared to observations using electromagnetic radiation.
- Explain how particles can be detected and their properties determined, and appreciate the limitations of different detection techniques.
- Identify the astrophysical observations which motivate the key features of the current cosmological models.
- Use a Newtonian-inspired model to describe the expansion of the universe. Account for the dynamics of the expansion of the universe during the radiation- and, subsequently, matter-dominated epochs. Defend the basic properties of the model with observational data.
- Discuss the hypothesis that the vast majority of the universe consists of forms of ('dark') matter and energy, the nature of which are not known today. Explain the independent observations which lead to this startling fact. Hypothesise over the possible particle candidates for the 'dark matter' of the universe.
- Perform dimensional analysis to define relationships between physical variables in astrophysical systems.
- Interpret data from figures published in the scientific literature and use this to perform calculations and develop conclusions.
- Reflect on the current 'open questions' in astroparticle physics and the experiments planned to address these issues.

Course contents

Review of the concepts of particle physics

a. The matter particles: leptons and quarks

b. The force carriers

c. The interactions (electromagnetic, weak and strong)

d. Problems with current theories

The contents and dynamics of the universe

a. Basis principles of cosmology

b. The distribution of matter and radiation in the universe

c. Dynamics of matter: redshift and Hubble's Law

d. Deductions from a Newtonian cosmological model – the critical density and geometry of the universe

Big Bang nucleosynthesis and thermal relics

a. The Planck era

b. The chronology of the Big Bang

c. Radiation, matter and the expansion of the universe

d. Temperature – time relationship

e. Nucleosynthesis

f. Antimatter in the universe

g. Thermal relics

The Cosmic Microwave Background and cosmological parameters

a. The discovery and origins of the cosmic microwave background

b. Anisotropies in the cosmic microwave background

c. Measuring the anisotropies and extracting cosmological parameters

d. Future experiments

Dark Matter - the missing mass of the universe

a. The dark matter problem

b. Dark matter candidates and experiments trying to find them

c. Present results and future prospects

The role of neutrinos in the universe

a. Interactions and cross-sections

b. Stellar and solar neutrinos

c. Neutrinos as probes of supernovae

d. Atmospheric neutrinos

e. High energy neutrinos

f. Neutrino detectors

g. Neutrino masses and oscillations

Cosmic rays: Galactic and at / near the earth

a. The discovery of cosmic rays on earth

b. Production and acceleration

c. Ultra-high energy cosmic rays and their detection

d. Sources of cosmic rays in the solar system

e. Solar and terrestrial effects on cosmic rays

f. Studying cosmic rays with balloon- and satellite-borne experiments

g. Cosmic gamma-rays

Course literature

Particle astrophysics, D. Perkins (2nd edition, 2009). OUP.

Hand-outs.

Examination

- INL1 - Home Assignments, 5.0 credits, grading scale: A, B, C, D, E, FX, F
- PRO1 - Seminar, 1.5 credits, grading scale: P, F
- LAB1 - Laboratory, 1.0 credits, grading scale: P, F

Based on recommendation from KTH's coordinator for disabilities, the examiner will decide how to adapt an examination for students with documented disability.

The examiner may apply another examination format when re-examining individual students.

If the course is discontinued, students may request to be examined during the following two academic years.

Home assignments (5 hp)

Seminar (1.5 hp)

Laboratory (1 hp)

Ethical approach

- All members of a group are responsible for the group's work.
- In any assessment, every student shall honestly disclose any help received and sources used.
- In an oral assessment, every student shall be able to present and answer questions about the entire assignment and solution.