UAB
Universitat Autònoma de Barcelona

High Energy Astrophysics

Code: 42856
ECTS Credits: 6

2025/2026

Degree	Type	Year
High Energy Physics, Astrophysics and Cosmology	OT	0

Contact

Name: Alessandro Patruno

Email: alessandro.patruno@uab.cat

Teachers

Francisco Javier Rico Castro

Abelardo Moralejo Olaizola

Alessandro Patruno

Teaching groups languages

You can view this information at the end of this document.

Prerequisites

It is mandatory to have followed the course of Introduction to the Physics of the Cosmos. It is also recommended - but not mandatory - to have followed the Observational Techniques course.

Objectives and Contextualisation

Students should become familiar with the basics of High Energy Astrophysics, not only with respect to the sources and astrophysical processes that produce X rays, gamma rays and cosmic rays in our universe, but also with the instruments that detect these photons / particles. The course is divided into three blocks. The first part is a theoretical description of the main processes of interaction of matter and radiation in the X- and gamma-ray energy domain. The second one describes the detectors that are currently operating, those under construction and those being designed. The third and final block presents the phenomenology of several cosmic sources of X rays, gamma rays, cosmic rays that have been observed so far.

Competences

- Formulate and tackle problems, both open and more defined, identifying the most relevant principles and using approaches where necessary to reach a solution, which should be presented with an explanation of the suppositions and approaches.

- Understand the bases of advanced topics selected at the frontier of high energy physics, astrophysics and cosmology and apply them consistently.

Learning Outcomes

1. Analyze the different sources of cosmic radiation.
2. Distinguish and analyze the different types of cosmic radiation detectors.
3. Understand the physical processes responsible for the emission, propagation and absorption of cosmic radiation (charged particles, photons and neutrinos).

Content

Outline of the Course

1.Introduction. Physical processes

Production of high-energy (X- and gamma-ray energy range) photons and cosmic rays.

Particle acceleration in the universe.

2. Observation methods

X- and gamma-ray instrumentation from space and ground-based. Cosmic-ray detectors.

Neutrino astronomy. Direct dark matter detection techniques.

3. The high-energy sky

Accretion-powered sources: white dwarfs, neutron stars and black holes in binaries. Active galactic nuclei.

Nova and supernova explosions. Supernova remnants, pulsars and pulsar wind nebulae

Gamma-ray emission related to nucleosynthesis. Diffuse and line emission

Gamma-ray emission related to matter anti - matter annihilation

Gamma-Ray Bursts

Cosmic rays: origin and propagation; possible acceleration sites

Gamma rays as probes of the intergalactic medium (extragalactic background light, magnetic fields)

4. Multi-messenger astronomy, fundamental physics aspects

Evidence for dark matter. Direct and indirect dark matter searches, possible candidates and signatures. Current limits from multi-messenger astronomy.

Tests of Lorentz invariance with multi-messenger observations.

Search for axion-like particles through cosmic- and gamma-ray propagation anomalies.

Activities and Methodology

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Lectures	45	1.8	1, 2, 3
Type: Supervised			
Oral presentation on a topic, based on a paper and associated references	35	1.4	1, 2, 3
Type: Autonomous			
Homework: study, check of the lecture notes and slides	65	2.6	1, 2, 3

Theory lectures.

Classwork and homework.

Annotation: Within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

Assessment

Continous Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Attendance and active participation to the lectures	10%	0	0	1, 2, 3
Final exam	45%	4	0.16	1, 2, 3
Oral presentation of a research topic	45%	1	0.04	1, 2, 3

Attendance to the lectures and active participation (e.g., asking questions) will be tracked

One final exam covering all the topics will be done (with a tentative duration of 2.5 hours).

Individual work on a research topic, based on a paper provided by the teachers and on the associated references found by the student, is required. A written report and its oral presentation, followed by a discussion with the panel (teachers of the master), should be done.

In case of failure, there will be the opportunity to pass the course with a new exam and / or the defense of a new essay; the threshold score to have the opportunity to recover is 3/10.

This subject/module does not foresee the single assessment system.

Bibliography

- Radiation Detection and Measurement, Glenn F. Knoll, Wiley, NJ, USA (2000)
- Exploring the X-ray Universe, Philip A. Charles, Frederick D. Seward, Cambridge University Press, Cambridge, UK (1995)

- Radiative Processes in Astrophysics, Rybicki, G. B. and Lightman, A. P., Wiley-VCH Verlag GmbH, Weinheim, Germany (1985)
- Very high energy cosmic gamma radiation : a crucial window on the extreme Universe, F. A. Aharonian, River Edge, NJ: World Scientific Publishing (2004)
- Accretion power in Astrophysics", J. Frank, A. King, D. Raine, Cambridge University Press (3rd Edition, 2002)
- High Energy Astrophysics", M.S. Longair, Cambridge University Press (2011) (also available as EBOOK)

Software

.

Groups and Languages

Please note that this information is provisional until 30 November 2025. You can check it through this link. To consult the language you will need to enter the CODE of the subject.

Name	Group	Language	Semester	Turn
(TEm) Theory (master)	1	English	second semester	morning-mixed