COURSE OF STUDY *Physics (LM-17)*

ACADEMIC YEAR *2024-2025*

ACADEMIC SUBJECT *Theoretical astroparticle physics*

General information	
Year of the course	2nd
Academic calendar (starting and ending date)	1st semester: September - December 2024
Credits (CFU/ECTS):	3
SSD	FIS/02
Language	English
Mode of attendance	Recommended, not compulsory

Professor/ Lecturer	
Name and Surname	Antonio Palazzo
E-mail	palazzo@ba.infn.it
Telephone	
Department and address	Physics Department, Office n. 138
Virtual room	
Office Hours (and modalities: e.g., by appointment, on line, etc.)	16:00-18:00 Monday

Work schedule			
Hours			
Total	Lectures	Hands-on (laboratory, workshops, working groups, seminars, field trips)	Out-of-class study hours/ Self-study hours
75	16	15	44
CFU/ECTS			
3	2	1	

Learning Objectives	To master the Theoretical Astroparticle Physics Topics treated in the lectures.
Course prerequisites	Special relativity. Basic knowledge of physics of fundamental interactions.

Teaching strategie	Frontal lessons.
Expected learning outcomes in terms of	
Knowledge and understanding on:	During the course, the student will be gradually introduced to the basic aspects and topics of modern theoretical astroparticle physiscs (TAPP). The student will acquire the ability to identify the most important interconnections between particle physics and cosmology.
Applying knowledge and understanding on:	At the end of the course the student should be able to use suitable mathematical methods to describe selected topics in theoretical astroparticle physics.
Soft skills	• *Making informed judgments and choices* At the end of the course, the student is expected to be able to deal independently and critically on the TAPP topics. Furthermore, he should be able to critically interpret the observational data. • *Communicating knowledge and understanding*

	At the end of the course, the student is expected to develop the ability to expose the fundamental concepts of the themes studied and to describe the relevant analytical calculation techniques, with clarity, rigor, and language properties. The acquisition of these skills will be accomplished through assiduous and continuous course attendance. ● *Capacities to continue learning* At the end of the course, the student will have acquired the basic skills to deepen the understanding of more complex concepts concerning TAPP and will be able to acquire new knowledge from textbooks and from research papers. These skills will be develop through participation in the discussion of case studies addressed during the lessons.
Syllabus	
Content knowledge	Observational evidences on the main properties of the Universe. Basic elements of General Relativity. The metric of Friedmann-Lemaitre-Roberstson-Walker. Dynamics of the early Universe. Thermodynamics of early Universe. Thermal history of the Universe. Boltzmann equation: equilibrium and decoupling. Nucleosynthesis. Matter-radiation equality. Hydrogen recombination and photon decoupling. Cosmic Microwave Background Radiation. The role of neutrinos. The problem of Dark Matter. Production of particle dark matter as a cosmological relic: freeze-out. Cold and hot dark matter. Weakly interacting massive particles (WIMPs). The "WIMP miracle". Different kinds of experimental searches of particle dark matter.
Texts and readings	E.W. Kolb, M.S. Turner: “The Early Universe” (Frontiers in Physics) L. Bergstrom, A. Goobar: “Cosmology and Particle Astrophysics” (Springer) S. Dodelson: “Modern Cosmology” (Academic Press)
Notes, additional materials	
Repository	

Assessment	
Assessment methods	The final evaluation will be based on an oral discussion of topics presented in the lectures. During the oral test the student will be invited to illustrate some of the topics covered in class.
Assessment criteria	● *Knowledge and understanding* Basic knowledge and TAPP topics treated in the lectures and of the main analytical calculations pursued during the course constitute the necessary condition for passing the exam. ● *Applying knowledge and understanding* Mastery of the analytical treatments studied and their application to various TAPP contexts represent the requirement for a very positive assessment of the exam. ● *Autonomy of judgment* Being able to judge independently the relevance of a theoretical issue or of an observational anomaly will demonstrate maturity and will be judged positively. ● *Communicating knowledge and understanding* The ability to clearly, rigorously and linguistically describe the topics covered during the course is considered essential for a positive examination outcome. ● *Communication skills* The ability to clearly communicate the topics covered during the course is considered important for the final examination.

	● *Capacities to continue learning* The ability to independently acquire further knowledge starting from the basis of the content transmitted during the course, as well as to make connections with other subjects of the course of study, are considered excellent qualities during the examination.
Final exam and grading criteria	In-depth reasoning, rigour, completeness. The student needs a mark of 18/30 to pass the examination.
Further information	
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