COURSE OF STUDY *Physics (LM-17)*

ACADEMIC YEAR *2024/2025*

ACADEMIC SUBJECT *High Energy Astrophysics*

General information	
Year of the course	1st
Academic calendar (starting and ending date)	2nd semester: March - May 2025
Credits (CFU/ECTS):	6
SSD	FIS/01
Language	English
Mode of attendance	Recommended, not compulsory

Professor/ Lecturer	
Name and Surname	Francesco Giordano
E-mail	Francesco.giordano@uniba.it
Telephone	+380805443170
Department and address	Dipartimento Interateneo di Fisica
Virtual room	Teams - k7xz4gr
Office Hours (and modalities: e.g., by appointment, on line, etc.)	Office R76 – su appuntamento

Work schedule			
Hours			
Total	Lectures	Hands-on (laboratory, workshops, working groups, seminars, field trips)	Out-of-class study hours/ Self-study hours
150	32	30	88
CFU/ECTS			
6	4	2	

Learning Objectives	Basis of experimental astrophysics, stellar evolution, cosmological principle and data-model interpretation Basis of special relativity and general relativity, principles of statistical and quantum mechanics applied to degenerate celestial bodies
Course prerequisites	Elementary particle physics, special relativity, statistical and quantum mechanics principles Radiation matter interaction and instrumentation for ionizing radiation measurement

Teaching strategies	Lectures, numerical practices, seminars on specific topics, reading and discussion of scientific papers on the course matter
Expected learning outcomes in terms of	
Knowledge and understanding on:	o Understanding the scientific method, the nature, and the methods of research in Physics o Knowledge of experimental particle physics related to astroparticles o Experimental measurements on optical astrophysics o Cosmological principle o The mail Sequence of Stars o Stellar evolution

	o Thermal and non-thermal Emission spectra o Principle of general relativity
Applying knowledge and understanding on:	o Ability to use analogy to apply known solutions to new problems (problem solving) o Ability to design and implement experimental or theoretical procedures to solve problems in academic and industrial research or to improve existing results o Ability to use analytical and numerical mathematical computation tools o Create connections between data and model in the field of general cosmology o Disentangle thermal from non thermal emission o Describe different astrophysical sources
Soft skills	● Making informed judgments and choices o Ability to work with increasing levels of autonomy, including taking responsibility in project planning and managing facilities. o Read and discuss scientific papers o Present and discuss results about subject treated in the course o Create autonomous connections among different subject of the course ● Communicating knowledge and understanding o Competence in communication in Italian and English in advanced fields of Physics o Present results in seminars o Discuss relevant scientific results o Write a report o Prepare reviews ● Capacities to continue learning o Acquisition of basic knowledge tools for continuous learning and knowledge updates o Identify a subject o Create a robust bibliography o Present results o Create multidisciplinary connections
Syllabus	
Content knowledge	Introductory outlines on High Energy Astrophysics 1.Universe structure: measurement techniques of astronomical distances, the Milky Way, large scale universe structure, galaxies classification, galaxies rotation curves, local group, galaxies clusters and super-clusters, universe expansion, Hubble law, red-shift, outlines on big bang. 2.Stellar evolution: star photometric quantities, Hertzprung-Russel diagram, historical development of star evolution theories, pp and CNO cycles, star clusters and star populations, star formation, star evolution, brown dwarfs, white dwarfs, giant stars, binary systems, Cepheids. 3.Supernovae: evolution, collapse, explosion, supernovae remnants, SN 187A, new stars generation. 4.Gamma astronomy: transparency of universe to e.m. radiation, gamma sources, Compton Gamma Ray Observatory, EGRET, Fermi satellite, non identified gamma sources, diffusion gamma radiation component, pulsars, Active Galactic Nuclei, dark matter. 5.Pulsars and black holes: properties and operation models of pulsars, binary pulsars, accreting disks, characteristics and detection techniques. 6.Active Galactic Nuclei (AGN): radio-galaxies, unified model of AGNs, Seyfert galaxies, BL-Lac, quasars, blazars, detection techniques. 7.Gamma ray burts: first observations, BATSE, Beppo-SAX, localization models, time characteristics, generation models, collapsars, Fermi-LAT observations.
Texts and readings	De Angelis-Pimenta - Introduction to Particle and Astroparticle

	Physics-Springer International Publishing (2018) Longair - High Energy Astrophysics Vol 1 (2Nd Ed) Thomas K. Gaisser - Cosmic Rays and Particle Physics-Cambridge University Press (1990)
Notes, additional materials	Specific chapters, slides, scientific papers
Repository	Slides, notes and scientific papers on Teams - k7xz4gr

Assessment	
Assessment methods	Oral examinations. Students may use digital support such as power point slides, tablets or paper support to discuss mathematical expression, most relevant physical laws or theorems or draw plots and graphs.
Assessment criteria	● Knowledge and understanding o Principles of Universe evolution o Stellar evolution o Emission spectra by astrophysical objects ● Applying knowledge and understanding o Principles of statistical mechanics and quantum mechanics applied to astrophysical bodies o Radiation matter interaction behind the emission spectra o General relativity applied to massive objects ● Autonomy of judgment o Create autonomous connections among different subjects ● Communicating knowledge and understanding o Seminar preparation o Discuss scientific papers ● Communication skills o Public speaking in a professional way ● Capacities to continue learning o Reading scientific papers and report the major results
Final exam and grading criteria	correct speaking (30%), precision in information details (30%), autonomy in connections (40%)
Further information	
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