COURSE OF STUDY *Physics (LM-17)*

ACADEMIC YEAR *2023-2024*

ACADEMIC SUBJECT *Multimessenger Astrophysics*

General information	
Year of the course	2nd
Academic calendar (starting and ending date)	1st semester: September - December 2023
Credits (CFU/ECTS):	3
SSD	FIS/05
Language	English
Mode of attendance	Recommended, not compulsory

Professor/ Lecturer	
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Department and address	Dipartimento Interateneo di Fisica, Via E. Orabona 4, 70125, Bari
Virtual room	
Office Hours (and modalities: e.g., by appointment, on line, etc.)	Every Tuesday, from 10 AM to 12 PM, with appointment

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	*Advanced knowledge of gamma-ray astrophysics in the multimessenger context. Main properties of extragalactic sources: focus on Active Galactic Nuclei (AGN) and Gamma-Ray Bursts (GRBs). Currently operating space- and ground-based observatories. Emphasis on the latest scientific breakthroughs in Multimessenger Astrophysics since 2017: (1) discovery of gravitational waves (GWs) and their association with electromagnetic counterparts, e.g. GRB 170817A (2) observation of neutrino emission from the direction of known blazars, e.g. TXS 0506+056*
Course prerequisites	*Basic astrophysics, Stellar physics, Cosmic Ray Physics*

Teaching strategie	*Classroom lessons / tutorials, supported by video projector and with the help of networked PCs, team building pre-, during and post- laboratory, exercises and peer-review.*
Expected learning outcomes in terms of	
Knowledge and understanding on:	• *Basic aspects of high-energy astrophysical phenomena* o *Focus on GRB physics and the connection with Gravitational Waves* o *Focus on AGN physics and the connection with Neutrino detections*
Applying knowledge and understanding on:	• *Ability to critically review and summarize a scientific article;* • *Ability to perform simple analysis of experimental data taken by the Fermi instruments;*

	Computer skills related to data processing and analysis as well as presentation of data sample.
Soft skills	*Making informed judgments and choices:* - *Ability to estimate and classify the analysed astrophysical sources depending on the relevant spectral and temporal properties* *Communicating knowledge and understanding:* - *Communication skills in English:* - *Presentation skills;* - *Skills in the exposition of experimental results using appropriate scientific language;* *Lifelong learning skills:* - *Ability to learn and to transfer simple experimental procedures.* *Ability to work in a group, and to be inserted quickly and effectively in the workplace*
Syllabus	
Content knowledge	1) *Detection of gamma radiation (satellite and telescopes): scintillation detectors, pair-production telescopes, Cherenkov telescopes.* - *Currently operating space missions: highlight on Fermi, with its two instruments, the Large Area Telescope (LAT) and the Gamma-Ray Burst Monitor (GBM).* - *Currently operating Cherenkov telescope: MAGIC, H.E.S.S. Prospects for the future Cherenkov Telescope Array (CTA).* 2) *Extragalactic sources visible at gamma-ray energies: focus on AGN and GRBs. Temporal and spectral characteristics. Multi-frequency studies. Open questions in the multimessenger context.* 3) *Gravitational wave theory and detection. Interferometers.* 4) *Neutrino detection principles. The IceCube experiment.* 5) *Multimessenger Astrophysics:* - *LIGO/Virgo GW detections from 2015 to 2020.* - *The case of GRB 170817A / GW 170817 as seen by LIGO/Virgo and Fermi.* *The case of neutrino emission from the TXS 0506+056 as seen by IceCube, Fermi and MAGIC.*
Texts and readings	*1. Spurio – "Probes of Multimessenger Astrophysics"* *2. Longair – "High-energy astrophysics"* *3. De Angelis & Pimenta - "Introduction to Particle and Astroparticle Physics"* *4. Recent Publications*
Notes, additional materials	*The main reference text is n.1. The other books can be consulted to review introductory and / or more specific concepts. A series of recent publications in the sector will also be presented during the course to deepen some aspects.*
Repository	

Assessment	
Assessment methods	*Final Report (70%), Oral exam (30%)*
Assessment criteria	● *Knowledge and understanding* o *Solid knowledge of basic principles of multimessenger astrophysics* ● *Applying knowledge and understanding* o *Capacity to identify and discuss various types of astrophysical sources like AGN and GRBs;* o *Capacity to estimate the errors of a measurement and to graphically represent the experimental data in an appropriate way;* ● *Autonomy of judgment* o *Capacity to evaluate, describe and discriminate the temporal and spectral properties of astrophysical sources, e.g. between short and long GRBs;* ● *Communicating knowledge and understanding* o *Ability to write a comprehensive summary report*

	● *Communication skills* o *Ability to present results in a clear and exhaustive way* ● *Capacities to continue learning* *Curiosity and interest in further studying and deepening the knowledge*
Final exam and grading criteria	*Clear and exhaustive final report; Solid knowledge demonstrated during the final oral exam. The final grade is awarded out of thirty. The exam is considered passed when the grade is greater than or equal to 18.*
Further information	