UNIVERSITÀ DEGLI STUDI DI BARI ALDO MORO

DIPARTIMENTO INTERUNIVERSITARIO DI FISICA

General information		
Academic subject	*Multimessenger astrophysics*	
Degree course	*Physics*	
Academic Year	*2021-2022*	
European Credit Transfer and Accumulation System (ECTS)	3	
Language	*English*	
Academic calendar (starting and ending date)	*October / November 2022*	
Attendance	*No*	

Professor/ Lecturer	
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Department and address	*Dipartimento Interateneo di Fisica, Via E. Orabona 4, 70125, Bari*
Virtual headquarters (Microsoft Teams code)	
Tutoring (time and day)	*Tuesday, from 10 AM to 12 PM.*

Syllabus	
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*
Contents	*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.*
Books and bibliography	*1. Spurio – "Probes of Multimessenger Astrophysics"* *2. Longair – "High-energy astrophysics"* *3. De Angelis & Pimenta - "Introduction to Particle and Astroparticle Physics"* *4. Recent Publications*
Additional materials	

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

Teaching strategy	*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	

Knowledge and understanding on:	• *Basic aspects of high-energy astrophysical phenomena*
	  ○ *Focus on GRB physics and the connection with Gravitational Waves*
	  ○ *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*

Assessment and feedback	
Methods of assessment	*Final Report (70%), Oral exam (30%)*

Evaluation criteria	• ***Knowledge and understanding***
	  ○ *Solid knowledge of basic principles of multimessenger astrophysics*
	• ***Applying knowledge and understanding***
	  ○ *Capacity to identify and discuss various types of astrophysical sources like AGN and GRBs;*
	  ○ *Capacity to estimate the errors of a measurement and to graphically represent the experimental data in an appropriate way;*
	• ***Autonomy of judgment***
	  ○ *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***
	  ○ *Ability to write a comprehensive summary report*
	• ***Communication skills***
	  ○ *Ability to present results in a clear and exhaustive way*
	• ***Capacities to continue learning***
	  ○ *Curiosity and interest in further studying and deepening the knowledge*

Criteria for assessment and attribution of the final mark	*Clear and exhaustive final report; Solid knowledge demonstrated during the final oral exam.*
Additional information	