PhD Physics course at Bari University (XXXIV Cycle)

Title	**Cosmology and Gamma-ray Astrophysics** Part I: Cosmology Part II: The Multi-messenger Context
Proponent	Part I: Giuseppe Fanizza Part II: Elisabetta Bissaldi
# CFU (2 CFU = 16 hours)	Part I: 1 Part II: 1
Schedule	Part I: April-May Part II: May-June
Brief Summary of the course	Part I: This part of the course is meant to face the theoretical challenges in modern cosmology from both the theoretical and observational viewpoints. In the first part, a summary of basic concepts and the main features of the Standard Cosmological model will be presented. This will provide the common background for the PhD candidates to discuss in more details the physics concerning the relativistic effects in the next generation experiments, with particular attention to Large-Scale Structures Surveys (Euclid, SKA, etc.) and CMB experiments. Part II: This part of the course aims to provide the student with advanced knowledge of gamma-ray astrophysics. It will explore the main properties of extragalactic sources, like Active Galactic Nuclei (AGN) and Gamma-Ray Bursts (GRBs) studied by the currently operating space- and ground-based observatories. Particular emphasis will be given to the latest scientific breakthroughs of 2017 and 2018, namely the discovery of gravitational waves associated with the short GRB 170817A, and the observation of neutrino emission from the direction of the blazar TXS 0506. It requires an elementary background in basic high-energy astrophysics.
Program	Part I: Late time Universe: Dark Energy and Dark Matter. Early time Universe: Cosmological Perturbation Theory, Inflation, the physics of Cosmic Microwave Background. From theory to observations: Relativistic Effects in the next generation experiments. Part II: Extragalactic sources visible at gamma-ray energies (focus on AGN and GRBs): temporal and spectral characteristics. Multi-frequency studies. Gamma-ray instruments, detection of gamma radiation: scintillation detectors, pair-production telescopes, Cherenkov telescopes. The case of GRB 170817A / GW 170817 in the context of other LIGO/Virgo gravitational waves detections from 2015 to 2017. The case of neutrino emission from the TXS 0506 as seen by IceCube, Fermi and MAGIC.

Recommended texts	1. Longair - "High-energy astrophysics" 2. De Angelis & Pimenta - "Introduction to Particle and Astroparticle Physics" 3. Durrer – "The Cosmic Microwave Background" 4. Dodelson – "Modern Cosmology" Recent Publications
Assessment methods	Lessons, final report