PhD course in Physics, Astrophysics, and Applied Physics - Università degli Studi di Milano
PhD cicle 40 (2024-2025)

All lectures will be given in English.

Course title	Observations of the Cosmic Microwave Background
Teacher in charge of the course	Marco Bersanelli
List of the teachers of the course *[surname/name; affiliation; e-mail]*	Bersanelli Marco, University of Milan, marco.bersanelli@unimi.it
Training objectives	• Provide an overview of the main experimental challenges involved in observations of the Cosmic Microwave Background (CMB) appropriate for a PhD student working out his/her research in a generic area of physics or astrophysics; • Describe the specific strategies in measurements of the CMB frequency spectrum, temperature anisotropies and polarization, and highlight their scientific impact; • Provide an overview of the current state-of-the-art and of future perspectives of CMB experiments. • Stimulate an interactive discussion with and among the students during the lectures and, where possible, identify interconnections with the research subject of each student.
Prerequisites *[please insert details and also **state whether the course has advanced contents** suitable for students with prior knowledge of the topics or is also suitable for students without prior knowledge]*	• There is no specific prerequisite, other than being engaged in a research project at the level of a PhD student in Physics or Astrophysics. • For students with a specific background on CMB science, some more technical contents will be provided. They will be also invited to contribute more actively in the discussions.
Detailed course program	• General definitions: flux density, antenna temperature, beam pattern. Discovery of the CMB and early observations • Measurements of the CMB frequency spectrum. Scientific motivations: blackbody spectrum and spectral distortions. Absolute calibration. Atmospheric contribution and Galactic foregrounds in absolute measurements. South Pole experiment, COBE/FIRAS. Total power and differential receivers. Radiometer equation. Systematic effects in absolute measurements: instability, straylight, atmospheric residuals, galactic foregrounds. State of the art and future perspectives. • Measurements of CMB anisotropies. Scientific motivations: origin of cosmic structures, measurement of cosmological parameters. Angular power spectrum, cosmic variance. CMB dipole. COBE/DMR, large and small scale anisotropies. Foregrounds for CMB anisotropies: dust, synchrotron, free-free, point sources. Dicke-switched radiometers, pseudo-correlation radiometers. Bolometric receivers. Cryogenic systems for CMB. Angular resolution and optical systems for CMB experiments. Ground based, balloon and space experiments. WMAP and Planck. • Measurements of CMB polarization. Motivations: cosmological parameters, probing inflation through B-modes. Experimental challenges in CMB polarization measurements. Galactic and extragalactic polarized foregrounds. CMB polarization from WMAP and Planck. State-of-the-art and future perspectives: large detector arrays from ground (Atacama, South Pole) and from space (LiteBIRD mission).
Examination modalities	The exam consists in a presentation by the Student focusing on a topic treated in the course, previously agreed with the lecturer, followed by a general discussion. Student are encouraged to identify, if possible, connections (in content or methodology) between the topics discussed in the course and their own research area.
Preliminary schedule *[please indicate the weeks when the lectures will be given]*	The course is typically delivered in the second or third week of April. However, the timing can be agreed with the students depending on everyone's schedule.