



UNIVERSITÀ  
DEGLI STUDI DI MILANO-BICOCCA

## COURSE SYLLABUS

### Experimental Cosmology

2627-1-F5803Q009

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#### Aims

**Knowledge of observational evidences and experimental techniques for cosmology.**

Dublin Descriptor 1 – Conoscenza e comprensione

Knowledge of observational evidences and experimental techniques in cosmology.

Dublin Descriptor 2 – Capacità di applicare conoscenza e comprensione

Apply the scientific method and data analysis methodologies to cosmological experiments and observations.

Dublin Descriptor 3 – Autonomia di giudizio

Critically evaluate experimental results and theoretical models in cosmology.

Dublin Descriptor 4 – Abilità comunicative

Communicate clearly using scientific language, both written and oral, in national and international contexts.

Dublin Descriptor 5 – Capacità di apprendimento

Independently consult and integrate advanced scientific publications for continuous updating

#### Contents

Elements of cosmology: the early Universe and its evolution. The standard model of cosmology and its observational probes. Cosmic Microwave Background: history and current status of measurements and results.

Physical observables, cosmological parameters and experimental techniques.

## **Detailed program**

### **Part 1: Introduction to Physical Cosmology**

- Historical Overview
- Cosmological principle
- Curvature and its implications
- Metric
- The Friedmann-Robertson-Walker metric
- Friedmann's equations
- Density parameters and cosmological constant
- Peculiar solutions to Friedmann's equations
- Benchmark model

### **Part 2 – Observational probes of the Big Bang model**

- Distance measurements: definitions
- Standard candles and standard rulers
- Cosmology with distance measurements
- The distance ladder
- Cosmological standard candles
- Type Ia supernovae
- The measurement of  $H_0$
- Discovery and meaning of the Cosmic Microwave Background
- Big Bang Nucleosynthesis
- Reionization
- HI mapping through the 21cm line

### **Part 3 Cosmic Microwave Background**

- Origin of the CMB blackbody
- Recombination, photon decoupling, last scattering
- History of CMB measurements
- Spectral distortions
- CMB anisotropies: basic quantities
- CMB power spectrum: structure and features and their physical motivation
- Temperature anisotropy measurements
- CMB instruments, experimental techniques, calibration, control of systematics
- From time ordered data to maps, to power spectra, to cosmology
- CMB Foregrounds
- CMB temperature anisotropy results
- CMB polarization anisotropies
- Primordial gravitational waves and inflation
- CMB polarization: current status and near future
- CMB statistics

### **Part 4 – Large scale structure and Galaxy Clusters**

- The matter power spectrum and the 2-point correlation function
- Baryon Acoustic Oscillations (BAO)

- Cosmological results from BAO
- Outlines of cosmology with gravitational Lensing
- Galaxy Clusters: definitions and properties
- Cosmology with Galaxy Clusters, SZ effect

## Prerequisites

## Teaching form

The course is 6CFU, for a total of 44 hours, divided into 22 2-hour sessions, which include lectures and exercises, all in instructional, traditional (*erogativo*) teaching way.

## Textbook and teaching resource

Course slides and notes

B. Ryden, Introduction to Cosmology

S. Serjeant, Observational Cosmology

Articles indicated during lectures

## Semester

Second semester

## Assessment method

### Oral exam (presentation + open questions)

The examination is on appointment with the teacher, will last between 30' and 1h, and it is composed of two parts:

#### Part 1:

A 15 minute presentation by the candidate, making use of slides and/or the blackboard on one of the course's topics (please send via email a PDF version of the slides before the examination). The candidate is required to investigate and present the topic by using the material and the bibliography shown during the course lectures. This part allows to assess the candidate's ability to present complex topics in a clear way, to further investigate the topics through scientific papers, and her/his analysis and synthesis skills.

#### Part 2

Questions and discussions, both on the presentation's topics, and on any other course's topic. This part allows to evaluate the candidate's understanding of any of the course topics, linking experimental results and theoretical

models to build the modern view of the Universe birth, evolution and composition.

## **Office hours**

Tue. 9:00-10:00 or by appointment

## **Sustainable Development Goals**

INDUSTRY, INNOVATION AND INFRASTRUCTURE

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