Course title:

INTRODUCTION TO COSMOLOGY

Duration [number of hours]: 24

PhD Program [MERC/MPS/SPACE]: SPACE

Name and Contact Details of Unit Organizer:

Prof. SABINO MATARRESE
Department of Physics and Astronomy G. Galilei, University of Padova, Italy
sabino.matarrese@pd.infn.it

Course Description [max 150 words]:

The course aims at providing an introduction to Modern Cosmology. I will first discuss the observational basis of the standard model of cosmology, both in terms of space-time symmetries and contribution of the various components to the present-day energy budget. I will then derive the so-called Friedmann equations which describe the evolution of the Universe on average over large enough scales. The main physical concepts which allow to describe the thermal history of the Universe, including the earliest phases of "inflation" (with the generation of density perturbations and cosmological gravitational waves), as well as some fundamental events (baryogenesis, nucleosynthesis of light elements, hydrogen recombination, decoupling of particle species, …). Finally, I'll discuss the process of cosmic structure formation, as well as the process of generation of cosmic microwave background anisotropies from primordial inhomogeneities.

Syllabus [itemized list of course topics]:

The Cosmological Principle and the Friedmann-Lemaître-Robertson-Walker model.
Present-day cosmic energy budget: observational evidence for dark matter and dark energy.
Derivation of the Friedmann equations.
Thermal history of the Universe: main concepts.
Kinematics and dynamics of inflation in terms of a scalar field. Quantum generation of scalar perturbations and gravitational waves (main concepts).
Baryogenesis (main concepts) and primordial nucleosynthesis of light elements.
Hydrogen recombination and last-scattering.
Decoupling of particle species and the origin of dark matter.
The perturbed Universe: formation of large-scale structure. Linear evolution and the Zel'dovich approximation.
Main properties of the Cosmic Microwave Background.
Cosmic acceleration and the dark energy puzzle.

Assessment [form of assessment, e.g. final written/oral exam, solutions of problems during the course, final project to be handed-in etc.]:

The final assessment can consist of either an oral examination focusing on the main concepts introduced during the course, or, alternatively, a presentation (short seminar) by the student where a specific topic covered during the course is analyzed in greater detail.

Suggested reading and online resources:

1. Lectures notes.
2. Lectures slides.
3. “An Introduction to modern cosmology”, by A.R. Liddle (2015)
4. “Cosmology”, by N. Vittorio (2017)