Course unit English denomination	Cosmology
SS	**PHYS-05/A Astrofisica, cosmologia e scienza dello spazio**
Teacher in charge	Nicola Bartolo Sabino Matarrese
Teaching Hours	24
Number of ECTS credits allocated	3
Course period	March – June 2026
Course delivery method	☒ In presence ☐ Remotely ☐ Blended
Language of instruction	English
Mandatory attendance	☒ Yes (50% minimum of presence) ☐ No
Course unit contents	- Standard cosmology: Fundamentals of General Relativity for cosmology; Cosmological models; Friedmann-Robertson-Walker metric - Thermodynamics of the Universe: elements of kinetic theory in the expanding Universe; evolution of the entropy and of the main thermodynamical quantities; photon and neutrino decoupling; relic particles - Inflation: problems of the standard cosmological model; kinematics and dynamics of inflation models; generation of primordial perturbations - Cosmic Microwave Background temperature anisotropies and polarization: main effects and their physical origin, dependence on cosmological parameters, connection to inflationary perturbations, in particular to primordial gravitational waves. - Gravitational Instability: linear evolution of perturbations; Jeans scale; free-streaming, models with dark matter and baryons; cold dark matter, hot dark matter, etc.. - Statistics of cosmological perturbations: power-spectrum; transfer function; filter functions; higher-order statistics - Non-linear evolution of perturbations: N-body techniques; spherical model; Zel'dovich approximation and adhesion theory. - Dark Energy: observational aspects; models. A LIST OF POSSIBLE ADVANCED TOPICS: - Techniques for computing primordial non-Gaussianity - Open quantum systems in cosmology - Non-linear and general relativistic cosmological perturbations
Learning goals	The "Cosmology" course aims first of all at providing a concise introduction

	to the current research in this field, both in the direction of Early Universe physics and Inflation and in the context of the late Universe (large-scale structure formation, evolution and statistical analysis) as well as at the phenomenological characterization of dark matter and dark energy. Emphasis will be given to some of the most up-to-date issues nowadays in cosmology. According to the audience, a selected list of advanced topics can be presented, tuned to the interests of the students. During the course students will be encouraged to read at least one or two papers on some topics of particular interest and to report them with a brief interactive discussion with all classmates. At the end of the course, the PhD students will be familiar with the most important concepts of cosmology, and their main implications (in terms of both modeling and observational constraints). The tools the students will acquire will allow them to solve problems related to the specific subject of the course but they will allow the students also to acquire a knowledge to face more general issues, e.g. those which might resemble the same complexity and approximation schemes learned during the course.
Teaching methods	Lectures will be given at the blackboard with the help of some slides. According to the audience, a selected list of advanced topics can be presented, tuned to the interests of the students. During the course students will be encouraged to read at least one or two papers on some topics of particular interest and to report them with a brief interactive discussion with all classmates. Therefore we will also • promote critical reflection in the classroom • conduct discussions in working groups in the classroom • use group work in the classroom
Course on transversal, interdisciplinary, transdisciplinary skills	☒ Yes ☐ No
Available for PhD students from other courses	☒ Yes ☐ No
Prerequisites (not mandatory)	Minimal knowledge of general relativity, but not mandatory, the course is self-contained
Examination methods (if applicable)	The students will be asked to prepare a short presentation (30 minutes approximately) with slides, on a topic proposed by the students that should be in connection with what has been explained during the course. The presentation will be based on the reading and study of one or more specific papers.
Suggested readings	- S. Dodelson, 2003. Modern Cosmology, Academic Press. - E.W. Kolb and M.S. Turner, 1990. The Early Universe, Addison-Wesley - A.R. Liddle and D.H. Lyth, 2000. Cosmological Inflation and Large-Scale Structure, Cambridge University Press. - S. Weinberg 2008, Cosmology, Oxford Univ. Press.

Additional information

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