UCLouvain

lphys2224 — Advanced cosmology and general relativity

2021

5.00 credits	30.0 h	Q2

Teacher(s)	Ringeval Christophe ;
Language :	English
Place of the course	Louvain-la-Neuve
Prerequisites	Having followed LPHYS1122 is an asset
Main themes	This teaching unit introduces the concepts and techniques required to ramp into modern cosmology and its foundations on applied general relativity. The theory of the cosmological perturbations, allowing for an accurate description of the weakly inhomogeneous universe, is explicitly derived from the Einstein's equations. Its application are presented, ranging from the anisotropies in the cosmic microwave background radiation, the formation of the large- scale structures to the propagation of gravitational waves in the universe. At the end of the teaching unit, modern research topics concerning the early universe and future observations are presented.
Learning outcomes	**At the end of this learning unit, the student is able to :** **a. Contribution of the teaching unit to the learning outcomes of the programme (PHYS2M and PHYS2M1)** 1.1, 1.2, 1.5, 2.1, 2.5, 3.1, 3.2, 3.3, 3.4, 4.1, 4.2, 5.1, 5.2, 5.3, 5.4, 7.1, 7.3, 8.1. 1 **b. Specific learning outcomes of the teaching unit** By the end of this teaching unit, the student will be able to : 1. understand, reproduce and check the results of basic research publications in cosmology ; 2. tackle down any calculations in general relativity.
Evaluation methods	Evaluation is based on a 2 hours long written exam that is focused on solving simple, but original, research-type problems in cosmology with a minimal amount of guidance. The problems require abstract modelling as well as being able to correctly perform calculations in general relativity.
Teaching methods	Teaching activities are alternating between traditional lecturing and guided learning. Calculations are detailed on the black board, in interacting style, while multimedia support is provided for numerical and data analysis results.
Content	The content of the teaching unit provides the tools needed to understand research results in cosmology and applied general relativity. In view of the active development of new X, optical, radio and gravitational telescopes the world is engaged in, the teaching unit may also be of particular interest for all physicists and engineers desirous to join the observatories and spatial missions of tomorrow. Lectures start from the following tree : • A description of the inhomogeneous universe - Measured CMB anisotropies and large-scale structures - Horizon and flatness problem, the origin of the inhomogeneities • Theory of the cosmological perturbations - Gauge invariance in general relativity - Scalar, vector and tensor decomposition - Perturbed metric and linearised Einstein equations - Perturbed stress tensor, gauge invariant fluid quantities - Density fluctuations, gravitational waves and power spectra • Cosmic microwave background anisotropies - Photon propagation in inhomogeneous space-times - Beyond the fluid approach : perturbed Boltzmann equations - Angular power spectra for scalars and tensors - Polarization and primordial gravitational waves - Initial conditions and parameter estimation • The early Universe

Bibliography	- "Primordial cosmology", Peter & Uzan. - "Physical foundations of Cosmology", Mukhanov. - "Cosmological Physics", Peacock. - "The Cosmic Microwave Background", Durrer. - "Modern Cosmology", Dodelson. - "General Relativity", Straumann. - "Relativity", Stefani. - "General Relativity", Wald.
Faculty or entity in charge	PHYS

Programmes containing this learning unit (UE)				
Program title	Acronym	Credits	Prerequisite	Learning outcomes
Master [120] in Physics	PHYS2M	5		🔍
Master [60] in Physics	PHYS2M1	5		🔍