UNIVERSITAT DE BARCELONA

Teaching plan for the course unit

General information

Course unit name: Advanced Cosmology

Course unit code: 568422

Academic year: 2019-2020

Coordinator: Enric Verdaguer Oms

Department: Department of Quantum Physics and Astrophysics

Credits: 6

Single program: S

Estimated learning time — Total number of hours 150

Face-to-face learning activities	60	
- Lecture	Face-to-face	48
- Lecture with practical component	Face-to-face	12
Supervised project	10	
Independent learning	80	

Recommendations

Students should have a previous knowledge of the following subjects taught in the bachelor's degree in Physics: Astrophysics and Cosmology; General Relativity and Quantum Mechanics.

Competences to be gained during study

Basic competences

— Knowledge forming the basis of original thinking in the development or application of ideas, typically in a research context.

— Capacity to apply the acquired knowledge to problem-solving in new or relatively unknown environments within broader (or multidisciplinary) contexts related to the field of study.

— Capacity to integrate knowledge and tackle the complexity of formulating judgments based on incomplete or limited information, taking due consideration of the social and ethical responsibilities involved in applying knowledge and making judgments.

— Capacity to communicate conclusions, judgments and the grounds on which they have been reached to specialist and non-specialist audiences in a clear and unambiguous manner.

— Skills to enable lifelong self-directed and independent learning.

General competences

— Capacity to effectively identify, formulate and solve problems, and to critically interpret and assess the results obtained.

— Capacity to write scientific and technical documents.

— Capacity to communicate, give presentations and write scientific articles in English on fields related to the topics covered in the master’s degree.

— Capacity to critically analyze rigour in theory developments.

— Capacity to acquire the necessary methodological techniques to develop research tasks in the field of study.

Specific competences

— Capacity to analyze and interpret a physical system in terms of the relevant scales of energy.

— Capacity to identify relevant observable magnitudes in a specific physical system.

— Capacity to test predictions from theoretical models with experimental and observational data.

— Capacity to understand and use current theories on the origin and evolution of the universe and to learn the observational data on which these theories are based.

— Capacity to critically analyze the results of calculations, experiments or observations, and to calculate possible errors.

Learning objectives

Referring to knowledge

— Understand the fundamental aspects of the current standard model of cosmology.

— Become familiar with the geometry and dynamics of Friedmann models.

— Understand the observational base for the existence of dark matter and dark energy, and its theoretical treatment.

— Understand the origin of the cosmic microwave background and the abundance of light elements.

— Learn some applications of the theory of phase transitions to cosmology.

— Understand the problems that have led to the inflationary model and the main physical and geometric characteristics of cosmic inflation.

Teaching blocks

1. Spacetime and the expansion of the universe

1.1. Cosmological principle; Spacetime geometry; Proper distance

1.2. Cosmological redshift; Expansion of the universe

1.3. Einstein’s equations; The static and stationary models

1.4. Friedmann equations; Radiation, matter and cosmological constant dominated expansion

1.5. Particle horizon

2. Observational cosmology and cosmic budget

2.1. Luminosity and angular distances; Mattig formula

2.2. Hubble diagram; Ages; Cosmic abundances; Baryons

2.3. Masses; The missing mass problem; Dark matter

2.4. Standard candels; Accelerated expansion; Dark energy

3. Large scale structure and cosmic microwave background radiation

3.1. The power spectrum of density fluctuations; The CDM model

3.2. Cosmic microwave background ratiation; Dipole and multipole anisotropies; Doppler peaks; Sachs-Wolfe effect

3.3. Concordance Lambda-CDM model

4. Thermal history, nucleosynthesis and recombination

4.1. Thermal history; Entropy density; Equilibrium distributions; Chemical potentials; Effective number of species; Neutrino decoupling

4.2. Nucleosynthesis; Neutron-proton conversion; Equilibrium nuclear abundances; Deuterium bottleneck; Light element abundances

4.3. Equilibrium, recombination and last scattering

5. The very early universe

5.1. The standard model of particle physics and the quark-gluon transition

5.2. Phase transitions in the early universe; Spontaneous symmetry breaking

5.3. Topological defects

5.4. Baryogenesis and leptogenesis; Sakharov's conditions

5.5. Dark matter candidates

6. Inflation

6.1. Flatness, horizon, curvature and monopole problems

6.2. General definition of *inflation*

6.3. Scalar fields in cosmology; Equation of state; Quintessence

6.4. Slow-roll inflation; Bubble formation; Slow-roll conditions; Thermalisation

6.5. Chaotic inflation and eternal inflation

Teaching methods and general organization

Lectures.
Expository classes.
Problem-solving activities.

Official assessment of learning outcomes

Written mid-semester tests (5/10)
Problem-solving exercises (5/10)
Repeat assessment: written final examination in June

Examination-based assessment

Final written examination (10/10)
Repeat assessment: written final examination in June

Reading and study resources

Consulteu la disponibilitat a CERCABIB

Book

Dodelson, Scott. *Modern cosmology*. Amsterdam [etc.] : Academic Press, cop. 2003

Kolb, Edward W. ; Turner, Michael S. *The early universe*. Reading (Mass.) [etc.] : Addison-Wesley, 1990

Linde, Andrei. *Particle physics and inflationary cosmology*. Amsterdam : Harwood Academic, cop. 1990

Mukhanov, V. F. *Physical foundations of cosmology*. Cambridge : Cambridge University Press, 2005

Peacock, John A. *Cosmological physics*, Cambridge : Cambridge University Press,1999

Peebles, P. J. E. *Principles of physical cosmology.* Princeton : Princenton University Press, cop. 1993

Weinberg, Steven. *Cosmology*. Oxford : Oxford University Press, 2008

Weinberg, Steven. *Gravitation and cosmology : principles and applications of the general theory of relativity*. New York [etc.] : Wiley, cop. 1972