COURSE DATA

DATA SUBJECT

Code: 43299
Name: Cosmology
Cycle: Master's Degree
ECTS Credits: 6
Academic year: 2026-27

STUDY (S)

Degree	Center	Acad. year	Period
2150 - Master's degree in Advanced Physics	Facultat de Física	1	First quarter

SUBJECT-MATTER

Degree	Subject-matter	Character
2150 - Master's degree in Advanced Physics	Advanced astrophysics	ELECTIVES

COORDINATION

MUÑOZ LOZANO JOSE ANTONIO

PLANELLES MIRA SUSANA

SUMMARY

Friedmann-Robertson-Walker (FRW) models. Inhomogeneities in the universe. Large-scale structure (observations). Statistical description of cosmic structure. The universe as a mixture of species interaction. The cosmological microwave background. Microwave background anisotropies

nd anisotropies

PREVIOUS KNOWLEDGE

RELATIONSHIP TO OTHER SUBJECTS OF THE SAME DEGREE

There are no specified enrollment restrictions with other subjects of the curriculum.

OTHER REQUIREMENTS

COMPETENCES / LEARNING OUTCOMES

2150 - Master's degree in Advanced Physics

Analizar una situación compleja extrayendo cuales son las cantidades físicas relevantes y ser capaz de reducirla a un modelo parametrizado.

Comprender de una forma sistemática el campo de estudio de la Física y el dominio de las habilidades y métodos de investigación relacionados con dicho campo.

Comprender la fase terminal de las estrellas que conduce a la formación de objetos compactos (enanas blancas, estrellas de neutrones o agujeros negros) incluyendo el colapso estelar que precede a la formación de estos objetos, incluyendo también fenómenos como las supernovas y las erupciones de rayos gamma.

Comprender los fundamentos teóricos de la física estelar y cómo se forman y evolucionan las estrellas a partir de aplicación de las leyes de la física.

Concebir, diseñar, poner en práctica y adoptar un proceso sustancial de investigación con seriedad académica.

Conocer los aspectos fundamentales de la cosmología observacional, incluyendo el estudio de galaxias por tipos y estructuras complejas y también la radiación de fondo de microondas y su estructura y anisotropías.

Elaborar una memoria clara y concisa de los resultados de su trabajo y de las conclusiones obtenidas en el área de la Física.

Estar en disposición para seguir los estudios de doctorado y la realización de un proyecto de tesis doctoral.

Evaluar la validez de un modelo o teoría propuesto por otros miembros de la comunidad científica.

Exponer y defender públicamente el desarrollo, resultados y conclusiones de su trabajo en el área de la Física.

Ostentar la preparación para tomar decisiones correctas en la elección de tareas y en su ordenación temporal en su labor investigadora y/o profesional.

Poseer la capacidad para el desarrollo de una aptitud crítica ante el aprendizaje que le lleve a plantearse nuevos problemas desde perspectivas no convencionales.

Realizar un análisis crítico, evaluación y síntesis de ideas nuevas y complejas en el área de la Física.

Saber modelizar matemáticamente los problemas físicos sencillos nuevos, conectados con problemas conocidos. Ser capaz de expresar en términos matemáticos nuevas ideas.

Saber organizarse para planificar y desarrollar el trabajo dentro de un equipo con eficacia y eficiencia.

Ser capaces de obtener y de seleccionar la información y las fuentes relevantes para la resolución de problemas, elaboración de estrategias y asesoramiento a clientes.

Ser capaz de gestionar información de distintas fuentes bibliográficas especializadas utilizando principalmente bases de datos y publicaciones internacionales en lengua inglesa.

Students should apply acquired knowledge to solve problems in unfamiliar contexts within their field of study, including multidisciplinary scenarios.

Students should be able to integrate knowledge and address the complexity of making informed judgments based on incomplete or limited information, including reflections on the social and ethical responsibilities associated with the application of their knowledge and judgments.

Students should communicate conclusions and underlying knowledge clearly and unambiguously to both specialized and non-specialized audiences.

Students should demonstrate self-directed learning skills for continued academic growth.

Students should possess and understand foundational knowledge that enables original thinking and research in the field.

DESCRIPTION OF CONTENTS

1. Friedmann-Robertson-Walker (FRW) Models

The cosmological principle, the Robertson-Walker metric and the background universe (FRW). Basic equations and free parameters in models including dark energy (cosmological constant or quintessence). The cosmological redshift z. Age of the Universe at redshift z. Cosmological distances.

2. Inhomogeneities in the universe

Random fields in cosmology. Description of the density fluctuations.
Power spectrum. Gravitational instability. Dynamic structure formation.
Baryon acoustic oscillations. Evolució no lineal. Tècniques numèriques i universos virtuals.

3. The universe as a mixture of interacting species

The species filling the universe and their proportions in each
cosmological period. Distribution functions in thermal equilibrium. The number density of photons and baryons. Liouville and Boltzmann equations in the FRW universe. Decoupling of species.

4. The cosmic microwave background (CMB)

Matter-radiation equilibrium for T >3500K: Black body spectrum. Recombination at T = 3500 K. Saha formula. The recombination studied with the Boltzmann equation: Residual ionization fraction. Matter-radiation decoupling. Silk damping. CMB evolution after decoupling (Liouville in FRW). Linear polarization of the CMB due to Thompson scattering during the recombination-decoupling process. Temperature constrast and angular correlations: deviations from gaussianity. Primordial contrasts at the decoupling epoch. Sachs-Wolfe, Doppler, and integrate Sachs-Wolfe contrasts. Non-gaussian effects: Rees-Sciama, lens, Sunyaev-Zeldovich, and Visniach. The angular power spectrum (Cl coefficients).

5. Observational Cosmology

Galaxies. The Local Group. Groups and clusters of galaxies. The macro-cosmic filaments walls and voids. Spectroscopic and photometric catalogs. Luminosity function. Peculiar velocities and virial theorem. X-ray emission: thermal bremsstrahlung. Estimates of mass and dark matter. Determination of cosmological parameters. Gravitational lenses: theory and observation.

6. Statistical description of cosmic structure

Distribution of galaxies and matter density field. Bias. Point processes. Counts in cells. Distribution function. Estimators of the correlation function. Effects of peculiar velocities. Real space and redshift space. Morphology and luminosity segregation. Cosmic evolution. Determination of cosmological parameters.

WORKLOAD

PRESENCIAL ACTIVITIES

Activity	Hours
Theory	39,00
Seminar	3,00
Other activities	4,00
Total hours	**46,00**

NON PRESENCIAL ACTIVITIES

Activity	Hours
Attendance at other activities	0,00
Individual or group project	0,00
Independent study and work	0,00
Preparation of lessons	52,00
Preparation for assessment activities	0,00
Resolution of case studies	52,00
Total hours	**104,00**

TEACHING METHODOLOGY

MD1 - Standard theory lecture.

MD3 - Problem solving.

MD4 - Problems.

MD5 - Seminars.

MD8 - Conferences of experts.

EVALUATION

Continuous assessment tasks will be carried out, such as the submission of exercises, reports and oral presentations, as well as, possibly, written tests on the contents of the subject. The assessment percentage for each part, both in the first and second call, will be as follows:

1) Grade of a written test on the contents of the subject: 40-50%

2) Grade of continuous assessment activities: 50-60%

To obtain a positive overall assessment, an average grade equal to or higher than 5 out of 10 must be obtained.

REFERENCES

- Introduction to cosmology, Barbara Ryden (Addison Wesley, 2001)
- An introduction to galaxies and cosmology, Mark H. Jones y Robert J.A. Lambourne(Cambridge University Press, 2003)
- Fundamentals of cosmology, James Rich (Springer, 2001)
- Cosmology. The origin and evolution of cosmic structure, P. Coles y F. Lucchin (Wiley, 1995)
- The large-scale structure of the universe, P.J.E. Peebles (Princeton Series in Physics, 1980)
- Principles of physical cosmology, P.J.E. Peebles (Princeton Series in Physics, 1993)

- Introduction to cosmology, Matts Roos (John Wiley & Sons Ltd, 1994)
- Measuring the universe. The cosmological distance ladder, Stephen Webb (Springer, 1999)
- Cosmology. The science of the universe (2nd edition), Edward Harrison (Cambridge University Press 2000)
- Cosmological Physics, John A. Peacock (Cambridge University Press, 1999) Structure formation in the universe, T. Padmanabhan (Cambridge University Press, 1993)
- Cosmology and astrophysics through problems, T. Padmanabhan (Cambridge University Press, 1993)
- Statistics of the galaxy distribution, Vicent J. Martínez y Enn Saar (Chapman & Hall/CRC, 2002)
- The distribution of the galaxies. Gravitational clustering in cosmology, William C. Saslaw (Cambridge University Press, 2000)
- The early universe, E. W. Kolb and M. S. Turner (Addison Wesley, 1994)
- The cosmic microwave background, R. Durrer (Cambridge University Press, 2008)
- Cosmology, S. Weinberg (Oxford University Press, 2008)
- Extragalactic Astronomy and Cosmology. An introduction. P. Schneider, (Springer-Verlag, 2006
- Cosmología Física, Jordi Cepa, (Akal, 2007)
- Data Analysis in Cosmology, Martinez et al. (eds). LNP 665, (Springer-Verlag, 2008)