COURSE DATA

Data Subject	
Code	43299
Name	Cosmology
Cycle	Master's degree
ECTS Credits	6.0
Academic year	2023 - 2024

Study (s)

Degree	Center	Acad. year	Period
2150 - M.D. in Advanced Physics	Faculty of Physics	1	First term

Subject-matter

Degree	Subject-matter	Character
2150 - M.D. in Advanced Physics	3 - Advanced astrophysics	Optional

Coordination

Name	Department
MARTINEZ GARCIA, VICENT JOSEP	16 - Astronomy and Astrophysics
MUÑOZ LOZANO, JOSE ANTONIO	16 - Astronomy and Astrophysics
PLANELLES MIRA, SUSANA	16 - Astronomy and Astrophysics

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

PREVIOUS KNOWLEDGE

Relationship to other subjects of the same degree

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

Other requirements

OUTCOMES

2150 - M.D. in Advanced Physics

- 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.
- 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.
- Saber organizarse para planificar y desarrollar el trabajo dentro de un equipo con eficacia y eficiencia.
- 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.
- Estar en disposición para seguir los estudios de doctorado y la realización de un proyecto de tesis doctoral.
- 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.
- Concebir, diseñar, poner en práctica y adoptar un proceso sustancial de investigación con seriedad académica.

- Realizar un análisis crítico, evaluación y síntesis de ideas nuevas y complejas en el área de la Física.
- Analizar una situación compleja extrayendo cuales son las cantidades físicas relevantes y ser capaz de reducirla a un modelo parametrizado.
- Evaluar la validez de un modelo o teoría propuesto por otros miembros de la comunidad científica.
- Saber modelizar matemáticamente los problemas físicos sencillos nuevos, conectados con problemas conocidos. Ser capaz de expresar en términos matemáticos nuevas ideas.
- Elaborar una memoria clara y concisa de los resultados de su trabajo y de las conclusiones obtenidas en el área de la Física.
- Exponer y defender públicamente el desarrollo, resultados y conclusiones de su trabajo en el área de la Física.
- 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.
- 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.
- 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.

LEARNING OUTCOMES

At the end of the teaching-learning process the student will have learned to:

1. Select and correctly use various sources of information in both traditional and electronic format.
2. Know the basics of databases and bibliographic resources typica of the field: inspire, spiers, arXiv.
3. Properly handle and interpret qualitative and quantitative physical data, which validate the known theories in the field.
4. Analyze information from physical systems.
5. Prepare written documents and reports in an understandable and organized way. Document and illustrate such documents.
6. Articulate structured, consistent, oral speech, with a good diction and use of technical vocabulary.
7. Understand the arguments used in the field of Astronomy and Astrophysics.
8. Understanding the mathematical description of physical processes governing the formation and evolution of celestial objects at both stellar and cosmological scales.

Being able to develop and manage the mathematical techniques and skills for their application in simple cases of the Einstein equations of gravitation.

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

Statistical description of cosmic structure. Distribution of galaxies and matter density field. Bias. Point processes.Counts per cell. Distribution function. Estimate of the correlation function. Effect of peculiar velocities. Real space and redshift space. Morphology and luminosity segregation. Cosmic evolution. Other descriptions of the macro cosmic fractal topological genus.

WORKLOAD

ACTIVITY	Hours	% To be attended
Theory classes	39,00	100
Other activities	4,00	100
Seminars	3,00	100
Preparing lectures	52,00	0
Preparation of practical classes and problem	52,00	0
TOTAL	**150,00**	

TEACHING METHODOLOGY

MD1 – Standard theory lecture.
MD3 – Problem solving.
MD4 – Problems.
MD5 – Seminars.
MD8 – Conferences of experts.

EVALUATION

SE1 - Written exam on the theory and practical lectures: based on the results of learning and the specific objectives of each subject (100%).

REFERENCES

Basic

- 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)