Astrophysics and Cosmology

Engineering Physics - elective course

Instructors: Jordi José & Domingo García-Senz

Language: English.

Bibliography

a) An Introduction to Modern Astrophysics (2nd Edition), B.W. Carroll & D.A. Ostlie, Pearson Addison-Wesley, 2007.
b) Introductory astronomy and astrophysics, M. Zeilik, S.A. Gregory, E. van Panhuys Smith, Saunders College Pub., 1992.
c) Fundamental Astronomy, H., Karttunen, P. Kröger, H. Oja, M. Poutanen, M., & K.J. Donner (Eds.), Springer Verlag 2007.
d) Stellar Explosions: Hydrodynamics and Nucleosynthesis, J. José, CRC/Taylor & Francis, 2016.

Invited seminars

a) Astronomical instrumentation: Gloria Sala
b) Mass measurements of neutron stars: Manuel Linares
c) White dwarf cooling and luminosity function: Santiago Torres
d) White dwarf binaries and type Ia supernovae: Alberto Rebassa-Mansergas

Project-based learning:

a) Integration of the equations of motion of a planet.
b) Free fall collapse.
c) Stellar evolution: simulations of light curves of binary systems.
d) Integration of zero temperature white dwarf structures: the mass-radius relationship.
e) Determination of the Hubble constant
f) Big Bang Nucleosynthesis.

Syllabus, instructors and approximate timetable:

1. Introduction (1 h, DG).

2. Planets and the Solar System (4 h, DG).

2.1. Equations of motion: Kepler's laws.
2.2. The Solar System.
2.2.1. Terrestrial planets.
2.2.2. Giant planets.
2.3. Exoplanets.

3. Stellar structure (18 h).

3.1. Relevant observational characteristics and timescales (2 h, DG).

3.2. Stellar interiors
3.2.1. The equations of stellar structure (3 h, DG).
3.2.2. Equation of state (2 h, DG).
3.2.3. Nuclear physics of stars (7 h, JJ).
3.2.4. Neutrino losses (1 h, JJ).
3.2.5. Sources of opacity (1 h, DG).
3.3. Stellar atmospheres (2 h, DG).

4. Stellar evolution (16 h).

4.1. The main sequence phase (1 h, DG).
4.2. Red giants (1 h, DG).
4.3. Stellar remnants: white dwarfs, neutron stars and black holes (6 h, DG).
4.4. Stellar explosions: classical novae, X-ray bursts and thermonuclear supernovae (8 h, JJ).

5. The Sun (4 h, JJ).

5.1. The radiative core.
5.1.1. Nuclear reactions.
5.1.2. Neutrino emission.
5.2. Convective layer.
5.3. Atmosphere.
5.3.1. Photosphere.
5.3.2. Chromosphere.
5.3.3. Corona.
5.4. The Solar cycle.
5.5. Solar activity.

6. Galaxies (5 h, DG).

6.1. The Milky Way.
6.2. Morphological classification of galaxies: the Hubble sequence.
6.3. Galactic chemical evolution.
6.4. Active galaxies and quasars.

7. Large-scale structure of the Universe (4 h, JJ).

7.1. Clusters of galaxies.
7.2. The extragalactic distance scale.
7.3. The accelerated expansion of the Universe.
7.4. Gamma-ray bursts.

8. Cosmology (5 h, JJ).

8.1. The observational basis of modern cosmology.
8.2. The cosmological principle.
8.3. Cosmological models.
8.4. The Big Bang and the inflationary Universe.

Evaluation: Final exam: 30%, Project-Based Learning: 70%.