PHYS10191 Physics Core Unit
Prof. T.J. O'Brien Credit Rating: 10

Introduction to Astrophysics and Cosmology

An introduction to astronomy with emphasis on the physical processes involved.

Prerequisites: A-level Physics

Follow-up units: PHYS10692 and Astronomy or Astrophysics options in later years.

Classes: 22 lectures in S1

Assessment: Tutorial work and attendance (5%)
Mid-semester test (10%)
1 hour 30 minutes examination in January (85%)

Feedback

Feedback will be offered by tutors on students' written solutions to weekly examples sheets, for which model answers will also be issued.

Recommended texts:

The following texts would provide useful additional reading:

Zeilik & Gregory, *Introductory Astronomy & Astrophysics,* 4th ed (Saunders College Publishing)
Morison, I., *Introduction to Astronomy and Cosmology* (Wiley)
Kutner, M.L., *Astronomy: A Physical Perspective* (Cambridge University Press)
Green, S.F. & Jones, M.H., *An Introduction to the Sun and Stars* (Cambridge University Press)
Jones, M.H. & Lambourne, R.J.A., *An Introduction to Galaxies & Cosmology* (Cambridge University Press)
Carroll, B.W. & Ostlie, D.A., *An Introduction to Modern Astrophysics* (Pearson)
Shu, F.H., *The Physical Universe, An Introduction to Astronomy*, (University Science Books)
Motz, L. & Duveen, A., *The Essentials of Astronomy*, (Colombia University Press)

Aims

To introduce the physical properties of astronomical objects and the Universe.

Learning outcomes

On completion successful students will be able to:

1. show a broad appreciation of the scale and astronomical contents of the universe and the astrophysical processes involved.
2. understand the optical design of refracting and reflecting telescopes and how their resolution is limited by the wave nature of light.
3. show how the fundamental properties of stars are measured – their luminosity, surface temperature, size, mass and distance – and how these are related by simple physical models.
4. describe the life cycle of stars of differing masses and the astrophysical processes that determine their evolution, including their source of energy, until they end their life as white dwarfs, neutron stars or black holes.

5. explain how we have learnt about the size and form of our own galaxy and the regions of gas and dust that can become the birthplace of new stars.
6. understand how the dynamics of galaxies and clusters indicate the presence of dark matter.
7. understand the dynamics of the solar system as determined by Newton's law of gravitation and describe several ways in which we can find planets orbiting other stars.
8. demonstrate an understanding of the origin and evolution of our Universe, including an appreciation of the evidence for the Big Bang and outstanding problems in cosmology.

Syllabus

1. Our place in the Universe: A tour of the Universe, its scale and contents (e.g. planets, stars, galaxies and the interstellar medium).

2. Observational astronomy: the electromagnetic spectrum; geometrical optics (ray diagrams, focal length, magnification etc); diffraction (resolving power, Airy disc, diffraction limit etc); telescopes (reflecting, refracting, multi-wavelength).

3. Properties of stars: brightnesses (luminosities, fluxes and magnitudes); colours (blackbody radiation, the Planck, Stefan-Boltzmann and Wien laws, effective temperature, interstellar reddening); spectral types; spectral lines (Bohr model, Lyman & Balmer series etc, Doppler effect); Hertzprung-Russell diagram; the main sequence (stellar masses, binary systems, Kepler's laws, mass-luminosity relations); distances to stars (parallax, standard candles, P-L relationships, m-s fitting etc); positions of stars (celestial sphere, coordinate systems, proper motions, sidereal and universal time).

4. The life and death of stars: energy source (nuclear fusion, p-p chain, triple-alpha, CNO cycle, lifetime of the Sun); solar neutrinos; basic stellar structure (hydrostatic equilibrium, equation of state); evolution beyond the main sequence; formation of the heavy elements; supernovae; stellar remnants (white dwarfs, neutron stars, black holes, degeneracy pressure, Swarszchild radius, escape velocities).

5. Planets & life in the Universe: formation of the stars and protoplanetary discs (molecular clouds, Jeans mass); contents of the solar system; planetary and cometary orbits; equilibrium temperatures; extrasolar planets (Doppler wobble, transits, microlensing; prospects); search for life elsewhere; SETI.

6. Galaxies: Constituents of galaxies; stellar populations; the interstellar medium; HII regions; 21cm line; spirals and ellipticals; galactic dynamics; galaxy rotation curves and dark matter; active galaxies and quasars.

7. Cosmology: Galaxies and the expanding Universe; Hubble's Law; the age of the Universe; the Big Bang; cosmic microwave background (blackbody radiation); big bang nucleosynthesis (cosmic abundances, binding energies, matter & radiation); introductory cosmology (the cosmological principle, homogeneity and isotropy, Olber's paradox); cosmological models (critical density, geometry of space, the fate of the Universe); dark energy and the accelerating Universe.