# . – Introduction to astronomy and astrophysics

## Proff. Roberto Auzzi; Massimo Della Valle

***COURSE AIMS AND INTENDED LEARNING OUTCOMES***

The course is addressed to second/third-year students in Mathematics and/or Physics intending to deepen their knowledge of Astronomy and Astrophysics. Astronomy is probably the oldest science. The paintings in *Lascaux* caves, in the department of Dordogne in southwestern France, show that our ancestors began to study the sky as soon as 20 thousand years ago. After providing a short historical introduction, we will approach the study of stars in their most relevant aspects: their structure, composition, mechanisms for energy production, and building chemical elements on which our life is based. We will also describe in some details the final stages of the life of a star, which ends through *Supernova* and *Gamma-ray Burst* explosions. Particular attention will be paid to the final products of stellar evolution, such as *Neutron stars* and *Black Holes* and the recent class of astrophysical objects labelled as *Kilonovae*, i.e. the electromagnetic counterparts of gravitational wave sources. We will illustrate an updated overview of the observational facilities operating from ground, such as the large telescopes of the European Southern Observatory in Chile, from space (e.g. *Hubble Space Telescope*) or *James Webb Space Telecope* and *LSST*. The final part of the course will address basic notions on our Solar System and the discovery of extrasolar planets and the probability to find life in other worlds.

***COURSE CONTENT***

**Module 1: The Roots of Modern Astronomy (3h)**

The Astronomy of Greece; The Ptolemaic Universe; Islam and Astronomy; The Puzzle of Planetary Motion; The Copernican Revolution; The Tycho Supernova; Galileo and Benedetto Castelli; Kepler's Three Laws of Planetary Motion.

**Module 2: The Sky as it appears (4h)**

Constellations; The Names of the Stars; The Brightness of Stars; Magnitude and Intensity; The Sky and Its Motion; The Celestial Sphere; Precession and Nutation; The Annual Motion of the Sun; The Seasons; The Motion of the Planets; Kepler laws; Theory of Eclipses.

**Module 3: Our Backyard and Life in Other Worlds (6h)**

The Solar System; Planet Earth; The Moon; The Sun; Mercury; Venus; Mars; Jupiter; Saturn; Uranus; Neptune; Asteroids, Comets, Dwarf Planets, Kuiper Belt and Oort Cloud; The structure of our Galaxy (The Milky Way); Life in Our Solar System; Life in Other Planetary Systems; Extrasolar Planets; How Many Inhabited Worlds? (Drake Equation)

**Module 4: Light and Telescopes (3h)**

The Electromagnetic Spectrum; Optical Telescopes; New-Generation Telescopes; Active and Adaptive Optics; Interferometry; The Spectrograph; Radio Telescopes; Infrared Astronomy; Ultraviolet Astronomy; X-Ray Astronomy; Gamma-Ray Telescopes; The Hubble Space Telescope.

**Module 5: Measuring the star parameters (4h)**

Distances to Stars; Intrinsic Brightness; Brightness and Distance; Absolute, Apparent and bolometric Magnitudes; Pogson Formula; photometric systems; Luminosity; The Sizes of the Stars; Luminosity, Radius, and Temperature relation; The H-R Diagram; Giants, Supergiants, and Dwarfs; Luminosity Classification; the Saha and Boltzmann equations; the Masses of Stars.

**Module 6: Stellar Structure and Formation (10h)**

Hydrostatic equilibrium, Mass continuity, Radiative energy transport, Energy conservation. Equation of state.

Scaling relation on the main sequence. Nuclear energy production, proton-proton chain. Convective energy transport.

Cloud Collapse and Star Formations. The Jeans Instability.

**MODULE 7: Stellar evolution and Stellar Remnants (10h)**

Star Evolution. Red Giant Phase. White Dwarf. Supernovae. Neutron stars. Pulsars. Introduction to Black Holes. Interacting Binaries.

***READING LIST***

Lecture Notes” provided by the lecturer.

***Consulting Books:***

“Astrophysics in a Nutshell” Maoz, D.,Princeton University Press, 2016

“Introduction to High Energy Astrophysics” S. Rosswog, M. Brüggen, Cambridge University Press

“The Cosmos: Astronomy in the New Millennium”Jay M. Pasachoff, Alex Filippenko,

Cambridge University Press

“Lezioni di Astronomia”, Rosino L., Edizioni CEDAM

***TEACHING METHOD***

Each module consists of about 3-14 hours of lectures which do not include the corrections and discussions of homework that will be carried out during the exam.

***ASSESSMENT METHOD AND CRITERIA***

Oral Exam. Discussion of three topics; the first one will be chosen by the student, the other two by the teachers. The assessment will be made on the basis of: i) the general degree of knowledge of the subject (30%); ii) the ability to answer to specific topics (30%); iii) homework (40%).

***NOTES AND PREREQUISITES***

The understanding of the course requires knowledge of basics of Mathematics and Physics, usually acquired in the courses of Analysis 1 – 2 and Physics 1 – 2.

The teachers will be available by appointment.

All appointments are agreed via email (massimo.dellavalle@inaf.it, roberto.auzzi@unicatt.it) and will be held remotely or in person at the headquarters in via Garzetta.