PHY-932 Astronomy and Astrophysics

Credit Hours: 3 (3+0)

Prerequisite: None

Course Objective: This postgraduate-level astrophysics course in astronomy and astrophysics aims to deepen students' understanding of the development of astronomy, various observational techniques used by astronomers, the life cycles of stars and their implications for astrophysical phenomena. Through advanced theoretical models and observational techniques, students will explore stellar formation, evolution, and endpoints. Emphasizing current research, students will analyze observational data, interpret theoretical frameworks, and critically evaluate literature. By course end, students will possess advanced knowledge and analytical skills to contribute to astrophysical research.

Course Contents: Introduction to astronomy and astrophysics, Interaction of radiation with matter, Stellar astrophysics I: Basic theoretical ideas and observational data, Stellar astrophysics II: Nucleosynthesis and other advanced topics, End stages of stellar collapse, Our Galaxy and its interstellar medium.

Detailed Course Contents: Introduction to astronomy and astrophysics: Historical background of astronomy; the emergence of modern astrophysics; mass, length and time scales in astrophysics; celestial coordinates and magnitude scales; applications of physics to astrophysics; sources of astronomical information; astronomy in different bands of electromagnetic radiations; astronomical nomenclature.
Interaction of radiation with matter: theory of radiative transfer; thermodynamic equilibrium revisited; Maxwell-Boltzaman velocity distribution; Saha equation; Boltzmann distribution; Planck’s law; local thermodynamic equilibrium; radiative transfers through stellar atmospheres; calculation of opacity; analysis of spectral lines.
Stellar astrophysics I: Basic theoretical ideas and observational data: Basic equations of stellar structures; hydrostatic equilibrium; virial theorem for stars; Jeans criterian for gravitational collapse; Shwarzchild stability condition; constructing stellar models; some relations among stellar quantities; a summary of the stellar observational data;

main sequence stars; red giants; white dwarfs; HR Diagrams.

Stellar astrophysics II: Nucleosynthesis and other advanced topics: The possibility of neuclear reactions in stars; calculations of nuclear reaction rates; important nuclear reactions in stellar interiors; detailed stellar models and experimental confirmation; stellar evolution; mass loss of stars; stellar winds supernovas; stellar rotation and magnetic fields; extrasolar planets.

End stages of stellar evolution: Degeneracy pressure of Fermi gas; structure of white dwarfs and Chandra mass limits; the neutron drip and neutron stars; pulsars; binary x-ray sources; accretion disks.

Our galaxy and its interstellar medium: the shape and size of the galaxy; galactic rotations; nearly circular orbits of stars; stellar population; in search of interstellar gas; phases of ISM and the diagnostic tools; the galactic magnetic field and cosmic rays; thermal and dynamical considerations.

Learning Outcomes: Students will be proficient in analyzing the intricate processes of star formation, evolution, and culmination. They will apply advanced theoretical models and observational techniques to understand stellar phenomena and characteristics. Additionally, students will critically evaluate current

research in stellar astrophysics and demonstrate the ability to analyze observational data and theoretical frameworks effectively. Ultimately, they will be equipped to contribute significantly to the field through independent research and critical thinking.

Text Book: Astrophysics for Physicists, by Arnab Rai Choudhuri, 2012 Cambridge University Press

Weekly Breakdown		
Week	***Section***	***Topics***
1	ARC 1.1 – 1.6	Historical background of astronomy; the emergence of modern astrophysics; mass, length and time scales in astrophysics; celestial coordinates and magnitude scales
2	ARC 1.7– 1.8	applications of physics to astrophysics; sources of astronomical information; astronomy in different bands of electromagnetic radiations; astronomical nomenclature

3	ARC 2.1– 2.2	Introduction to radiative transfer theory; radiation fields; energy density of radiations; radiative transfer equation; optical depth and solution of radiative transfer equation; Kirchoff's law
4	ARC 2.3– 2.4.1	Theromdynamic equilibrium revisited; maxwellian velocity distribution; saha equation; Boltzmann equation; concept of the local thermodynamic equilibrium; plane parallel atmosphere
5	ARC 2.4.2 – 2.7	The grey atmosphere problem; formation of spectral lines; radiative energy transport in stellar interiors; Thomson scattering; negative hydrogen ions; analysis of spectral lines
6	ARC 3.1 – 3.2.4	Basic equations of stellar structures; hydrostatic equilibrium in stars; virial theorem for stars; jeans criterion for gravitational collapse; energy transport in stars
7	ARC 3.3 – 3.5	Constructing stellar models; some relations among stellar quantities; stellar spectra; nearby stars; binary stars; mass luminosity relations; HR diagrams of nearby stars
8	ARC 3.6– 4.2	Eddington luminosity limit; HR diagrams of star clusters; the possibility of nuclear reactions in stars; calculation of nuclear reaction rates
9	**Mid Term Exams**	
10	ARC 4.3– 4.5	Important nuclear reactions in stellar interiors; detailed stellar models and experimental confirmation; stellar evolution in binary systems
11	ARC 4.6– 4.9	Mass loss of stars; supernovas; stellar rotation and magnetic fields; extrasolar planets
12	ARC 5.2–5.4	Degeneracy pressure of Fermi gas; Chandra mass limit and white dwarfs; the neutron drip and neutron stars; pulsars; binary x- ray sources
13	ARC	Some basics of star count analysis; Shapley's model; interstellar

	6.1 – 6.3	excitation and reddening; galactic coordinates; galactic rotation; nearly circular orbits of stars
14	ARC 6.4 – 6.6	Stellar population; In search of the interstellar gas; HI clouds; warm intercloud medium; molecular clouds; HII regions Hot coronal gas
15	ARC 6.7 – 6.8	The galactic magnetic field and cosmic rays (CR); thermal and dynamical considerations; a practical session to analyze astrophysical data.
16	**Final Exams**	