Course Type	Course Code	Name of Course	L	T	P	Credit
DE	NPHD518	NUCLEAR ASTROPHYSICS	3	0	0	3

Prerequisite:

Knowledge of Nuclear Physics including Nuclear Reactions is essential. Introduction to Quantum Mechanics, Mathematical Physics and Statistical Physics will be beneficial to understand this course.

Course Objective

The objective of the course is

- To provide a glimpse of what is happening inside the stars and how we can peek inside it with the help of nuclear physics;
- To motivate students to choose a career in related areas of physics;
- To prepare a base for an ambitious physics student who wants to go to advanced studies or research in relevant fields. They will be able to orally present new research results in the field to the other participants of the course.

Learning Outcomes

Upon successful completion of this course, students will:

- Able to understand what is the connection of nuclear physics to astrophysics and how the elements on earth are created.
- Eligible for higher studies in nuclear astrophysics
- Will be familiar with the basic ideas of nucleosynthesis.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	**Introduction:** Astrophysics- 'Explaining' the universe; General characteristics of Thermonuclear reactions; Sources of nuclear energy; nuclear fusion at astrophysical energies, Coulomb barrier and barrier penetration, mean lifetime; Maxwell-Boltzmann velocity distribution, Gamow peak and Gamow window, Astrophysical S – factor, abundance curve, astrophysical temperature.	9	This unit provides a broad knowledge of nuclear physics and nuclear astrophysics. It will help us in knowing how nuclear physics is involved in astrophysics.
2	**Determination of reaction rates:** thermonuclear cross sections and nuclear reaction rates in non-degenerate stars, stellar reaction rates, radiative capture reactions., direct reaction rates, resonant reaction rates. Spectroscopic factor of a state of a nucleus having astrophysical importance. Weisskopf units.	9	This unit gives a broad knowledge of the theoretical models that explain the origin of elements in the universe (nucleosynthesis).
3	**Nuclear burning stages in stars:** p-p chain, hydrogen, and helium burning, CNO cycles, Ne-Na cycle, Mg-Al cycle; Creation and survival of ^{12}C, Hoyle state. Big Bang nucleosynthesis. The structure and evolution of stars. Cosmological Li problem.	7	This unit will help students in understanding how the different elements were created and how life began in the universe.
4	**Explosive Burning and Nucleosynthesis beyond Iron:** Silicon burning; Nucleosynthesis in massive stars, Nucleosynthesis beyond iron peak (s-process, r–process, p-process), waiting-point in nucleosynthesis, Supernova explosion, Neutron and proton drip nuclei and Neutron Stars. Nucleocosmochronology	7	This unit is related to the information regarding the creation of heavier elements in the universe.
5	**Indirect methods in Nuclear Astrophysics:** Coulomb dissociation, Trojan Horse, and ANC methods	5	This unit tells what are the alternative measurements techniques in nuclear astrophysics.
6	**Nuclear Astrophysics in the laboratory**: Need for underground laboratories, Radioactive ion beams as a new experimental technique, Accelerators for beams of charged particles, neutrons and gamma rays, detectors, and target materials, and background-free measurements.	5	This unit helps in explains the relevant nuclear-astrophysical measurements and observations.
	Total	**42**	

Textbooks:

1. Rolfs C E and Rodney W S, "Cauldrons in the Cosmos : Nuclear Astrophysics", The University of Chicago Press (2005).
2. Christian Iliadis, "Nuclear Physics of Stars", 2007, Wiley.

Reference Books:

1. Clayton D D, "Principles of Stellar Evolution and Nucleosynthesis", The University of Chicago Press (1984)
2. Boyd R, "An Introduction to Nuclear Astrophysics", The University of Chicago Press (2008)