

## **Paper-14A**

### **Galaxies and Particle Astrophysics**

**Group A: Compact Objects, Interstellar Medium & Galaxies.**

**[36 lectures]**

#### **Compact Objects**

**[24 lectures]**

Black holes and compact objects. White Dwarfs and Neutron Stars, Compact X-Ray Sources, Radio Pulsars, Supermassive and other Black Holes, Gamma-Ray Bursters.

**[4L]**

Collapse of stars and formation of black holes; singularities and trapped surfaces, event horizon; Schwarzschild Black Hole, Tortoise Coordinates and Null Cones, The Kruskal Extension, Penrose Diagram - the Conformal Structure of Infinity. Kerr Black Hole; Boyer-Lindquist Coordinates, ergosphere; Weyl-Papapetrou form of the Kerr Metric, uniqueness of the Kerr solution. Dark Energy stars. Black hole accretion and accretion disk properties.

**[10L]**

White Dwarfs and Classification. Equation of State below the Neutron Drip Density, Structure of White Dwarfs and the Chandrasekhar Mass, Polytropic Approximation, Relativistic Instability of White Dwarf Stars, Necessary Condition for Stability, Total Energy in the Post-Newtonian Limit, GR White Dwarf Instability.

**[5L]**

Structure of a Neutron Star, Equations of State beyond Neutron Drip, From Neutron Drip to Saturation, Nuclear EoS for Dense Neutron Matter. Structure of Massive Neutron Stars. Periastron Shift, Shapiro Time Delay in a Binary System.

[5L]

Reference Books:

1. M. Camenzind, Compact Objects in Astrophysics
2. Stuart L. Shapiro and Saul A. Teukolsky, Black Holes, White Dwarfs, and Neutron Stars – The Physics of Compact Objects
3. Sean Carroll, Spacetime and Geometry
4. J. B. Hartle, Gravity – An Introduction to Einstein’s General Relativity

### **Interstellar Medium and Galaxies**

**[12 lectures]**

Interstellar medium and star formation: Interstellar dust and gas, formation of proto-stars, pre-main sequence evolution, initial mass function

[5L]

Galaxies: The Milky Way, Distribution of stars, Morphology, Kinematics, Neutral hydrogen(HI 21cm line)---Dark matter, Galactic Center, Normal galaxies: morphological classification, physical characteristics and kinematics, Intergalactic Medium.

[7L]

## Reference Books:

1. An introduction to the theory of stellar structure and evolution by Dina Prialnik (Cambridge University Press)
2. Physics of the Interstellar and Intergalactic Medium by B. T. Draine (Princeton Series in Astrophysics)
3. Galaxies in the Universe by Sparke and Gallagher, Cambridge University Press (2007)
4. An Introduction to Modern Astrophysics by B. W. Carrol and D. A. Ostlie (Pearson, 2006)
5. Galactic Astronomy by J. Binney & M. Merrifield (Princeton Series in Astrophysics)
6. Galactic Dynamics by J. Binney & S. Tremaine (Princeton Series in Astrophysics)

## **Group B: Standard Model and Astroparticle Physics**

**Standard Model [24 Lectures]**

Standard Model of Particle Interactions, Classical Field theory: Noether's Theorem and applications.

[4L]

Quantum Field Theory: Quantization of the Klein-Gordon, Dirac and Electromagnetic Field.

[10L]

Gauge theories of electromagnetic and weak interactions.

[6L]

Spontaneous Symmetry breaking and elementary idea about the Higgs' mechanism.

[4L]

Reference Books:

1. A first course in quantum field theory by A. Lahiri & P. B. Pal
2. Quarks and Leptons: an introductory course in modern particle physics by F. Halzen & A. D. Martin.

**Astroparticle Physics  
Lectures]**

[12

Astroparticle physics in perspective: Relationship to High Energy Physics, Astrophysics and Cosmology. Elementary particle processes in galactic, intergalactic and atmospheric production and transmissions, Physics of particle and radiation detection.

[4L]

Acceleration mechanisms in sunspots, supernovae shocks and accreting binaries.

[4L]

Primary and secondary cosmic rays: Charged and uncharged components: neutrino, gamma, x-ray and gravitational wave astronomy. Secondary cosmic rays: Atmospheric propagation, cosmic rays at the sea level and underground, Extensive air showers (elementary theory).

[4L]

## Reference Books:

1. Vanessa Cirkel-Bartelt - History of Astroparticle Physics
2. Claus Grupen : Astroparticle Physics
3. Donald Perkins: Particle Astrophysics
4. Claus Grupen : Particle Detectors