PHY-469 Introduction to Cosmology

Credit Hours: 3-0

Prerequisite: None

Course Objective:

This course is designed for non-science students and provides a technical but fundamental introduction to modern cosmological concepts. We will discuss improvements in cosmology during the last century, with a focus on more recent breakthroughs in the subject. We will discuss issues spanning from the early cosmos to galaxy creation in the present day cosmos, all through the lens of the theory of relativity and the expanding Universe. We will discuss the Big Bang, the Cosmic Microwave Background (CMB), dark matter, dark energy, and the evidence supporting these phenomena.

After midterms, students will concentrate on quantifying the universe's expansion rate using "fake" data generated by the computer. This will involve rudimentary measurements and minor spreadsheet-style calculations. Every student is assigned a different world with unique qualities, and the purpose of the final project – using the concepts covered throughout the semester – is to determine which universe is yours. This manner, students will gain a deeper comprehension of the issue.

Course Contents:

A brief history of Cosmology – from a theory to original science, Infinite space and absolute time, the special theory of relativity, the general theory of relativity, black holes, the expanding Universe, modeling the Universe, the Early Universe, testing our models, a message from Big Bang, dark matter and large scale structures, the inflationary Universe, the edge of time.

Detailed Course Contents:

Historical background of cosmology, cosmology becomes a science, Newton's mechanics, lighting the world, the lives of stars, the physical Universe, time in the Universe, the initial condition of the Universe, the cosmological principle, coordinate system defined, the relativity of space-time, Galilean relativity, summarizing the theory of electromagnetism, Einstein and the special theory of relativity, Einstein and the search for general theory of relativity, Einstein's relativity, the ether rejected, time dilation and length contraction, The meaning of the Lorentz transformation, more

transforms, space – time, light cones, paradoxes in SR, Summarizing electromagnetism in SR, the need for general relativity, the equivalence principle, two view points on the nature of space, a brief introduction to geometry, The metric equation, the structure of general relativity, tidal forces in space – time, locally flat space and globally curved spaces, a glimpse of Einstein's field equations, tests of general relativity, A look at the Schwarzchild solutions, the gravitational redshift revisited, properties of black holes, light cones of black holes, Rotating black holes, black holes with no hair, hawking radiations, black hole exotica, black holes in the present Universe, The discovery of the external universe, The cosmic distance ladder, the Hubble's law, The theoretical discovery of a dynamic universe, A metric for an expanding universe, The cosmological redshift, a Newtonian Universe, the standard models of the Universe, Hubble's law and scale factor, observations of standard models, Models with cosmological constant, approaching the Big Bang, a brief history of the Universe – radiation era, matter and energy, fields of dreams, the beginning of time, The parameters of the Universe, The Hubble constant and redshift–distance relations, The age of the universe, The geometry of space again, the mass of the Universe, Lambda or dark energy, The era of precision cosmology, Darkness and the expanding universe, noise from the sky, travelling photons, studying CMB Where are we going?, ripples in space – time, galaxies formation and evolution, an inflating universe, the edge of time.

Learning Outcomes:

- Students will be able to learn the concepts of cosmology in a very Layman manner. They will learn about the models, dynamics and evolution of the Universe.
- Students will also be able to understand the current and future works in the field of cosmology.
- With the end semester project they will be able to play with the real life cosmological data and they will learn and understand how to play with cosmological simulations.

Text Book:

Foundations of Modern Cosmology, 2nd Edition, by John F. Hawley and Katherine A. Holcomb, Oxford University Press (2005). (JHKH)

Weekly Breakdown		
Week	***Section***	***Topics***
1	JHKH introduction	Historical background of cosmology, cosmology becomes a science, Newton's mechanics, lighting the world, the lives of stars
2	JHKH Chapter 6	the physical Universe, time in the Universe, the initial condition of the Universe, the cosmological principle, coordinate system defined, the relativity of space-time
3	JHKH Chapter 6	Galilean relativity, summarizing the theory of electromagnetism, Einstein and the special theory of relativity, Einstein and the search for general theory of relativity
4	JHKH Chapter 7	Einstein's relativity, the ether rejected, time dilation and length contraction, The meaning of the Lorentz transformation, more transforms, space – time, light cones, paradoxes in SR
5	JHKH Chapter 8	Summarizing electromagnetism in SR, the need for general relativity, the equivalence principle, two view points on the nature of space, a brief introduction to geometry
6	JHKH Chapter 8	The metric equation, the structure of general relativity, tidal forces in space – time, locally flat space and globally curved spaces, a glimpse of Einstein's field equations, tests of general relativity
7	JHKH Chapter 9	A look at the Schwarzchild solutions, the gravitational redshift revisited, properties of black holes, light cones of black holes
8	JHKH Chapter 9	Rotating black holes, black holes with no hair, hawking radiations, black hole exotica, black holes in the present Universe
	Mid Term Exams	

9	JHKH Chapter 10	The discovery of the external universe, The cosmic distance ladder, the Hubble's law, The theoretical discovery of a dynamic universe, A metric for an expanding universe
10	JHKH Chapter 11	The cosmological redshift, a Newtonian Universe, the standard models of the Universe, Hubble's law and scale factor, observations of standard models
11	JHKH Chapter 12	Models with cosmological constant, approaching the Big Bang, a brief history of the Universe -- radiation era, matter and energy, fields of dreams, the beginning of time
12	JHKH Chapter 13	The parameters of the Universe, The Hubble constant and redshift–distance relations, The age of the universe, The geometry of space again, the mass of the Universe
13	JHKH Chapter 14	Lambda or dark energy, The era of precision cosmology, Darkness and the expanding universe, noise from the sky, travelling photons, studying CMB
14	JHKH 15	Where are we going? ripples in space – time, galaxies formation and evolution, an inflating universe, the edge of time
15		Revisions