PEP 335 Observational Astrophysics

Week 1	Review of astrophysical propagation of information via photons and particles. Introduction to instrumentation techniques
Week 2	Earth's atmosphere: absorption, scattering, turbulence. Site selection for observatories. Near-Earth space: conditions and optimization of satellite orbits. Spacecraft launch.
Week 3	Review of radiation, luminosity, and magnitude. Space-time reference systems for observations.
Week 4	Overview of telescope optics across the electromagnetic spectrum, coherent and incoherent sources
Week 5	Diffraction and image formation, adaptive optics for ground-based telescopes
Week 6	Interferometry methods for optical and radio telescopes
Week 7	Quantum and thermal noise, individual photon detection with the photoelectric effect, Compton scattering, and pair creation
Week 8	Radio telescopes, observations, and analysis methods
Week 9	Millimeter and sub-millimeter telescopes, observations, and analysis methods
Week 10	Optical and infrared telescopes, observations, and analysis methods
Week 11	Ultraviolet and X-ray telescopes, observations, and analysis methods
Week 12	Gamma-ray telescopes, observations, and analysis methods
Week 13	Cosmic ray instruments and analysis methods
Week 14	Gravitational wave detection techniques and analysis methods

Prerequisites:
PEP 112, PEP 151

Corequisite:
PEP 336

Textbook: Observational Astrophysics (3rd ed) by Pierre Lena, Springer, 2012.

Course Description:

This course focuses on the detection principles and technology of modern telescopes and observatories. Data analysis and instrumentation projects are an essential component of the course. Topics covered include: propagation of astrophysical information via photons and particles, the Earth's atmosphere, spacecraft design and launch, telescope optics, interferometry techniques, and a systematic survey of detection techniques from radio to gamma-ray telescopes and astro-particle instruments.

Course Outcomes:

1. Describe the propagation of astrophysical information via photons and particles and the effects of Earth's atmosphere on ground-based detection.
2. Apply optical principles to design and characterize basic telescopes.
3. Carry out simple calculations for diffraction and identify the concept of coherent radiation, which is essential to forming images.
4. Build and design a simple telescope, demonstrating photon detection principles.
5. Explain the techniques applied over a range of telescope instrumentations to detect photons across the electromagnetic spectrum based on the photoelectric effect, Compton scattering, and pair production mechanisms.
6. Conduct basic astrophysical data analysis, utilizing tools provided by NASA and other astrophysical resources.
7. Present original astrophysical results in both written and oral forms.