Modern Astronomical Optics

Spring 2014

Lecturers: Guyon, Hinz, Burge, Breckinridge, Martin

Graduate-level course to be offered in Spring 2014 semester - listed in Astronomy and Optics depts. The course consists of lectures + 4 team projects.

Course Description

This course provides an overview of astronomical optical systems for astronomy. It introduces astronomical and optical concepts related to exoplanets observations. By focusing on a particularly challenging observational problem of modern astronomy, the course will teach design and analysis of high precision optical systems and measurement techniques for astronomy, including spectroscopy, photometry, optical metrology and interferometry. Design and fabrication of both ground-based and space-based astronomical observatories and instruments will be discussed.

The course consists of lectures and team projects. For each of the four team projects during the semester, astronomy and optics students will work together to design a mission/telescope/instrument for astronomy, using material presented during the lectures. Each team projects will result in an oral presentation.

Units

3 credits
Tues Thurs, 9:30am - 10:15am
Course offered in Spring 2014
home department : optics

Prerequisites

Available for either graduate or undergraduate credit

Multiple Listings

Joint with Optical Sciences and Astronomy departments

Lectures

Course introduction, Fundamentals of astronomical imaging systems

This part of the course serves as an introduction to the course, and introduces fundamental concepts of astronomy and optics which will be explored in more details during the rest of the course. Connect astronomy to telescope and instrument requirements. Introduction of units used for astronomy and how they relate to radiometric quantities.

- Introduction to course
- Fundamentals of astronomical imaging systems: diffraction limit, photon noise

Optical systems for space-based scientific remote sensing

- Fundamentals of space-based imaging systems
- System engineering
- Project management

Fundamentals of Telescope design

- First-order design: plate scale, field of view, pixel size, diffraction limit
- Telescope types: refractive, reflective
- Wide field of view designs and aberration correction
- Space and ground: cryogenic telescopes, design choices, challenges
- Measuring large optics
- Fabrication challenges and solutions (large optics fabrication, integrating optics and telescope structure)

Spectrographs for Astronomy

- Fundamentals of spectroscopy: science goals, prisms, gratings, spectral resolution, detector sampling, wavelength coverage
- Types of spectrographs: slit, multi-object, Integral Field Units (IFUs)

Interferometry

- What does an interferometer measure ?
- First-order design: angular resolution, wavelength. Applications to stellar

diameter measurement, exozodiacal dust detection, exoplanet detection, image synthesis.
- Beam combination in interferometers
- Phase correction in interferometers: delay lines and adaptive optics
- Interferometry on a single aperture: aperture masking, speckle interferometry

Adaptive Optics

- Introduction to adaptive optics systems
- Atmospheric turbulence and its effect on image quality
- Wavefront sensing for adaptive optics
- Wavefront correction
- Laser guide stars
- Wide field of view correction: ground-layer, multi-conjugate and multi-objects adaptive optics
- System design, control strategies

High Contrast Imaging (nulling interferometry & coronagraphy)

- High contrast imaging science: exoplanets and disks
- Coronagraphs
- High contrast imaging systems

Team Projects

There will be 3 team projects (photometry, astrometry/interferometric nulling, direct imaging/wavefront control). For each team project, several (2 to 3) teams will design an optical system (full system, telescope or instrument for a telescope) to observe exoplanets. The result of this work will be presented to the class, and a short report will be compiled. The duration of a team project, from assignment to final report due date, is approximately 3 weeks.

Grades and Exams

50% of the grade is derived from the team projects, 50% from a 45-mn long oral exam.

Textbooks

The following texbooks are suggested for reference, but not required:

- Astronomical Optics (Shroeder)
- Exoplanets (Seager)