ASTR/OPTI 516

Astronomical Optics

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Units:

3 credits
Tues Thurs – 9:30am → 10:15am
Course offered in Spring 2011
home department : optics

Prerequisites:

Available for either graduate or undergraduate credit

Multiple Listings:

Joint with Optical Sciences and Astronomy departments

Brief description:

This class teaches optical techniques used for astronomy. For several important types of systems, students will work in small teams to solve problems and develop designs.

Expected enrollment:

10 optics students + 10 astronomy students

Syllabus

What material graduate students will be responsible for if co-convened
Undergraduate students will not have an oral final exam
Graduate students will have a final oral exam

Course Objectives
Provide overview of main requirements for optical systems in astronomy, introduce optical concepts and definitions specific to astronomical imaging systems. Teach the optical design and analysis of existing and future astronomical telescopes and instruments.

Learning Outcomes

- understanding requirements on optical systems imposed by astronomical applications
- understanding of optical principles and techniques used in astronomy: image formation, spectroscopy, interferometry, adaptive optics, coronagraphy
- ability to design optical systems for astronomical use

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

Adaptive Optics in Astronomy (2004), by Francois Roddier (Editor), Cambridge University Press
Adaptive Optics for Astronomical Telescopes (1998), by John W. Hardy, Oxford University Press
Astronomical Optics (Shroeder)
The Design and Construction of Large Optical Telescopes (Bely)
Reflecting Telescope Optics I and II (Wilson)

<u>Course outline</u>

Fundamentals of astromomical imaging systems
Connect astronomy to telescope and instrument requirements. Introduction of units used for astronomy and how they relate to radiometric quantities.
- Field of view
- Angular resolution, imaging quality (PSF)
- Sensitivity (throughput, thermal emission in IR)
- Spectral information
- Polarimetric information
- Time domain astronomy

Fundamentals of telescope design
- Telescope types: refractive, reflective
- Wide field of view designs and aberration correction
- Fabrication challenges and solutions (large optics fabrication, integrating optics and telescope structure)
- Space vs. ground: cryogenic telescopes, design choices, challenges

team project #1 : Telescope design
- first-order design (plate scale, FOV, pixel size, diffraction limit)
- introduction to aberrations with field of view

Spectrographs for astronomy
- Dispersion with optical elements: prisms, gratings, grisms
- Types of spectrographs: slit, multi-object, IFUs
- Spectrograph design: spectral resolution and coverage, angular resolution

team project #2 : Spectrograph design
- first-order design: spectral resolution, detector sampling, wavelength coverage, re-imaging optics, dispersing element

Interferometry
- What does an interferometer measure ?
- Beam combination in interferometers
- Phase correction in intereferometers: delay lines and adaptive optics
- Interferometry on a single aperture: aperture masking

team project #3 : Interferometer design

first-order design: angular resolution, wavelength

applications to stellar diameter measurement, exozodiacal dust detection, exoplanet detection, image synthesis

Adaptive optics

Atmospheric turbulence and its effect on image quality
Introduction to an adaptive optics system
Wavefront sensing for adaptive optics
Wavefront correction
Laser guide stars
Wide field of view correction: Multi-conjugate and Multi-object adaptive optics

team project #4 : Adaptive optics system design

first-order design: from required image quality to main design parameters

High contrast imaging (nulling interferometry & coronagraphy)

High contrast imaging science: exoplanets and disks
Coronagraphs
Nulling interferometry
High contrast imaging and wavefront control from the ground
High contrast imaging from space

Number of exams/papers

One paper per team project
One final oral exam (for graduate students only)

Grading Criteria:
Clearly explain the basis on which all grades will be assigned.
Provide a detailed list of all factors considered in assigning grades, with weighting (i.e. what percent of the grade is assigned to each factor).

Grades will be derived from class participation, project reports and presentations, and an oral final exam.

Class participation: 20% (40% for undergrads)

Project reports and presentations: 30% (60% for undergrads)
For each team project, a written report and short oral presentation will be given.

Oral final exam: 50% (no oral exam for undergrads)
30mn long oral final exam.

Grading Scale:
Explain how the overall course grade is assigned based on the sum of the various grading factors (e.g. 90-100% of possible points is a grade of A, etc).

85-100% : A
75-85% : B
65:-75% : C
50-65% : D
<50% : E