Astronomical Telescopes and Instruments

Introduction to the Course

Christoph U. Keller

Outline

Instrumentation for Astronomers: Why?

Prime Reasons

- Instrument will exactly do what you want it to do
- First observations with the instrument
- Superb instrument knowledge leads to better science

Why not Engineers?

- few optical engineers
- few systems engineers
- instrumentation research is experimental physics

Job Prospects

- NOVA spends the same amounts on science and on instrumentation
- ample PhD and permanent positions
- excellent experience for industry jobs

Astronomical Telescopes & Instruments: NS-AP443M

Goal (7.5 ECTS)

Understand how to build optical telescopes and instruments as an astronomer

People

- Christoph Keller (Chair of Experimental Astrophysics)
- Frans Snik (Postdoc Experimental Astrophysics)
- Maria de Juan Ovelar (PhD student Experimental Astrophysics)
- Gerard van Harten (PhD student Experimental Astrophysics)

Communication

- Through Blackboard
- Email addresses on course web page

Course Web Page

Course URL

www.astro.uu.nl/~keller/Teaching/AstroInstr_2010

Contents

- contact information
- course schedule, subscribe to iCal link
- lecture presentations, exercises, exercise materials, practicum materials
- presentation topics and assignments including links to papers (only from UU computers)

OSIRIS

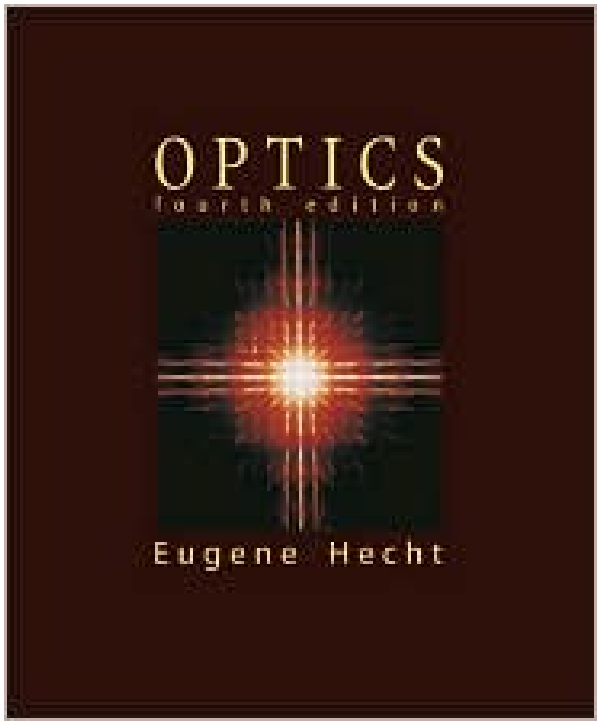
The course web page takes precedence over OSIRIS.

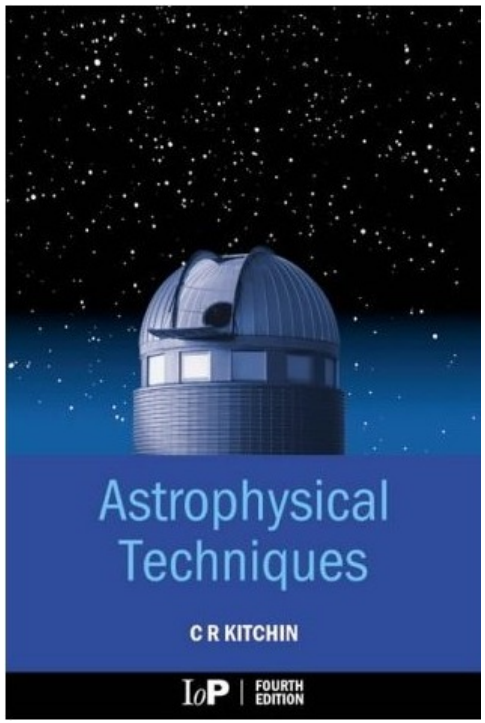
Lecture Notes and Books

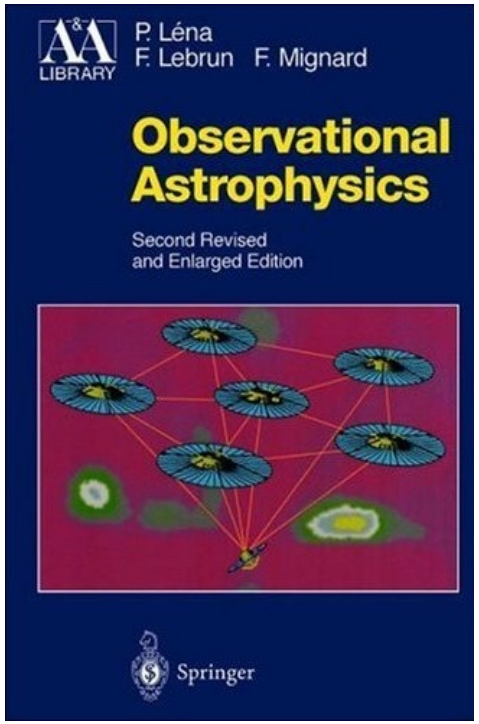
Lecture Notes

- various documents will be distributed during the course

Recommended Books







Course Schedule and Requirements

Weekly Schedule

Day	Time	Location	Topic
Wednesday	09:00 – 10:45	BBL 322/325	Exercises/Presentations
Wednesday	11:00 – 12:45	BBL 322/325	Lectures
Friday	11:00 – 12:45	BBL 005	Lectures
Friday	13:15 – 17:00	BBL 112	Computer Practicum

Exercises and Practicum

- exercises and practicum are integral part of course
- written exercises and reports have to be submitted by deadline
- will be checked, returned, and discussed
- solutions will not be made available in writing

Presentations

- select one original paper and present it to peers
- 30-minute presentation in English
- public and private discussion of presentation
- grade is for level of understanding of paper

Lectures

Title	Chapter	Instructor
Foundations of Optics	Hecht 1-4	Keller
Excursion to Dwingeloo		Snik
Geometrical Optics 1	Hecht 5	Keller
Geometrical Optics 2	Hecht 6	Keller
Polarization		Keller
Interference, Diffraction and Fourier Optics		Keller
Thin Films		Keller
Optical Design and Systems Engineering		Snik
Telescopes		Snik
Spectrographs 1		Keller
Spectrographs 2		Keller
Polarimeters		Keller
Interferometers		Keller
Detectors 1		Keller
Detectors 2		Keller
Seeing and Adaptive Optics		Keller
Manufacturing, Assembly, Integration and Testing		Keller

Outline

1. Electromagnetic Waves
2. Material Properties
3. Electromagnetic Waves Across Interfaces
4. Fresnel Equations
5. Brewster Angle
6. Total Internal Reflection

Lecture 2: Geometrical Optics 1

Outline

1. Introduction
2. Limitations
3. Lenses: thin and thick
4. Mirrors

Lecture 3: Geometrical Optics 2

Outline

1. Images and pupils
2. Optical systems
3. Phase Fronts
4. Wavefronts
5. Aberrations

Lecture 4: Polarization

Outline

1. Polarized Light in the Universe
2. Descriptions of Polarized Light
3. Polarizers
4. Retarders

Lecture 5: Interference, Diffraction and Fourier Theory

Outline

1. Interference
2. Coherence
3. Fringes
4. Intensity interference
5. Frauenhofer and Fresnel Diffraction
6. Scalar Diffraction Theory
7. Fourier Optics
8. Point-Spread Function and Modulation Transfer Function

Outline

Lecture 7: Optical Design and Systems Engineering

Outline

1. Requirements Definition
2. Ray-Tracing and Design Analysis
3. Optimization: Merit Function
4. Tolerance Analysis: Interaction with Optomechanical Design
5. Wavefront Error Budget
6. Transmission Budget

Outline

1. From Small Refractors to Large Reflectors
2. Optical Configurations
3. Segmented Mirror Telescopes
4. Wide-Field Telescopes
5. Telescope Mounts: Equatorial vs. Alt-Az
6. Focal Stations and Image Rotation

Lecture 9: Spectrographs 1

Outline

1. Astrophysical Spectroscopy
2. Broadband Filters
3. Fabry-Perot Filters
4. Interference Filters
5. Prism Spectrograph
6. Fourier Transform Spectrometer

Lecture 10: Spectrographs 2

Outline

1. Diffraction Gratings
2. Grating Spectrograph
3. Fibers
4. Multi-Object Spectrographs
5. Integral Field Units

Lecture 11: Polarimeters

Outline

1. Polarimeters
2. Rotating Waveplate Polarimeters
3. Liquid Crystal Polarimeters
4. HARPS Polarimeter
5. VSM Polarimeter
6. SPEX Polarimeter

Outline

1. Spatial and Temporal Coherence
2. Etendue of Coherence
3. Aperture Synthesis
4. Earth-Rotation Aperture Synthesis
5. VLTI

Lecture 13: Detectors 1

Outline

1. Overview
2. Photoconductive Detection
3. Charge Coupled Devices

Lecture 14: Detectors 2

Outline

1. CCD Review
2. CMOS and CMOS Hybrid Detectors
3. Array Detector Properties
4. Array Detector Data Reduction
5. Array Detector Problems

Lecture 15: Adaptive Optics

Outline

1. Seeing
2. Concept of Adaptive Optics
3. Wavefront Sensing
4. Wavefront Correctors
5. Adaptive Optics Control
6. Laser Guide Stars
7. Multi-Conjugate Adaptive Optics

Lecture 16: Manufacturing, Assembly, Integration and Testing

Outline

1. Lens and Mirror Manufacturing
2. Optical Testing
3. Alignment
4. Science Verification
5. Operations and Maintenance

Exams and Grades

Exams

- content
  - lectures
  - corresponding sections of lecture notes
  - exercises (computer and home work)
  - paper presentations and questions
- written exam after course ends
- oral exams after that
- mock exam before end of lectures

Grades

- 20% presentation
- 20% exerciseses and practicum reports
- 60% exam

Papers for Presentations

Topic	Paper with Link to ADS	Student Name	Presentation Date
FORS	Moehler et al. 1995		15.12.2010
HARPS	Mayor et al. 2003		12.1.2011
COROT	Auvergnet et al. 2009		19.1.2011
Hinode SP	Lites et al. 2007		19.1.2011
MIDI	Leinert et al. 2003		26.1.2011
NACO	Brandner et al. 2002		26.1.2011