Astronomy 433/533

Observational Techniques

Lectures: 11:00-12:15 Tuesday/Thursday, 310 Gallalee

Instructor: Dr. Keel, 316 Gallalee, 348-1641

Text: *Astrophysical Techiques*, by C.R.Kitchin (5th edition, CRC Press)

The beginning of coverage of each chapter and the page ranges covered are given in parenthesis for each lecture. Some topics (marked with asterisks) are not treated in the text, or have more that I want to say; there are extensive web-based lecture notes in addition to the textbook for these:
http://astronomy.ua.edu/keel/techniques

Primary learning goals for this class are:

- Learning to perform astronomical observations with eye, telescope, and modern detectors
- Understanding principles of data analysis, model fitting, and error analysis
- Gaining familiarity with current software tools for these tasks
- Acquiring ability to carry out and report a complete research project, from concept and data collection to analysis and conclusions

Preliminary Lecture schedule

13 January *No class* (AAS meeting)

18 Jan Introduction: far-field detection of radiation, its measurement and (mis)interpretation. We deal with the atmosphere, telescopes and related optics, detection, processing, and auxiliary instruments. Stokes-parameter approach. Photon and wave applications.

20-25 Jan (1, 1-51) Detectors: the human eye, photomultipliers, charge-coupled devices, other types (including IR arrays)

27 Jan (1,41-44) Noise and signal-to-noise optimization. Statistics of Poisson processes*, model fitting and testing*

1-3 Feb Sept Jan (1, 51-107) Telescopes: image formation, diffraction, aberrations, focal surfaces, *optical fibers.
Visual use: eyepieces, magnification
Designs: refractors
reflectors: prime-focus, Newtonian, Cassegrain, Ritchey-Chretien, coude' systems
catadioptric systems (Schmidt cameras)

8 Feb optional space-astronomy lecture at Bryant Conference Center (10:15-11:45)

10 Feb Optical fundamentals, collimation, alignment. Shaping and testing optical components.

15 Feb (1, 110-114) Telescope structures and mountings: tubes
mountings: equatorial: German, yoke, fork, horseshoe altazimuth, alt-alt
Tracking and acquisition; moving targets*
Atmospheric seeing, high-speed imaging*, and adaptive optics

17 Feb (1, 127-130) Observatory sites and enclosures; dome seeing, thermal and climatic effects
Atmospheric absorption and transmission windows
Robotic telescope operations*
Light pollution and electromagnetic interference issues

22 Feb Spacecraft-borne astronomy: orbital considerations*, pointing, attitude control and determination*

24 Feb Past and present space observatories, use of archival data*

1 Mar (1, 131-153) Radio and microwave detection (continuum and line)
Radio telescopes - single dish and cross antennae

3 Mar (1, 153-184) X-ray and gamma-ray detection
imaging: modulation collimation, grazing-incidence optics, narrow-band coated mirrors*, masks

8 Mar (2, 23-240) Imaging: the inverse problem, deconvolution, *image display and processing

First essay (case study of a selected observational technique) due

10 Mar (2, 240-Imaging at the telescope:
Guiding, focal locations*
Historical considerations: photography*

22 Mar (2, 259-263, 325-328) Electron imaging
Arrays, scanned detectors, drift scanning*, image stacking*

24 Mar (2, 264-298) Interferometry
2-element case: fringe pattern, Fourier treatment
Multiple elements - image reconstruction. Deconvolution again.
Aperture synthesis, VLBI

29 Mar (2, 298-325) Optical/IR work: Fabry-Perot, Fourier-transform spectrometer.
Speckles (imaging and spectrometry). Seeing theory.
Occultation imaging, relation to planetary/stellar eclipses.
Radar - terrestrial and space-based.

31 Mar (3) Photometry - emphasis on I. Whole art in details.
Absolute/differential. Single/multistar applications.
Filter/detector (photometric) systems.
Inferring stellar parameters.

5 Apr Photometry continued: Atmospheric extinction and dispersion.
Techniques: photoelectric, CCD, photographic, even visual
DC/pulse counting with photomultipliers
Time series, period analysis*

7 Apr (4) Spectroscopy and spectrophometry - emphasis on ν
Gratings/prisms/etalons
Spectroscopes - point-source, longslit, 2D*, multiobject*, integral-field units*
Slits, image slicers, fibers*, matching telescope and seeing

12 Apr Handling spectroscopic data: calibration, reduction, spectrophotometry

14 Apr (5.1) Astrometry - emphasis on θ_1, θ_2
coordinate systems and transformations
spherical trig and matrix formulations

19 Apr Precession, nutation, aberration of starlight

21 Apr (5.2) Polarimetry - emphasis on Q,U,V
broad-band, single-channel and imaging
spectropolarimetry

26 Apr Case studies in data analysis. When possible, keep the end in mind at the beginning and put your effort where it does the most good.

28 Apr Data presentation and assessment
graphics standards*
interaction with eye and brain*
ethics in research*
some career advice*

5 May (normal exam date) **Final written proposal due**

Grading and exams: There will be regular homework assignments, both paper and digital. In addition, there will be several observing projects for students enrolled in AY533 (these will be extra credit for 433 students). The final exam will be a mock observing proposal in take-home format, adhering to formats used by national observatories or space facilities (typically 4 pages, single spaced). There will be hands-on observing sessions using our campus observatory and the remote SARA observatories. Scheduling of these always depends on the weather, but both SARA telescopes have been scheduled for the nights of **February 3, March 10, and April 7**.

Writing assignments: This course carries a W designation. As such, writing proficiency is required for a passing grade in this course; a major essay assignment (detailing the application of a selected astronomical technique to a current problem; 5 pages double-space) early in the term, and the final proposal, will be graded both on technical content and the quality of the writing.

Other important information:

Academic misconduct: All students in attendance at the University of Alabama are expected to be honorable and to observe standards of conduct appropriate to a community of scholars. The University expects from its students a higher standard of conduct than the minimum required to avoid discipline. Academic misconduct includes all acts of dishonesty in any academically related matter and any knowing or intentional help, or conspiracy to help, another student. The Academic Misconduct Disciplinary Policy will be followed in the event of academic misconduct.

Students with disabilities are encouraged to register with the Office of Disability Services (348-4285). Thereafter, you are invited to schedule appointments to see me during office hours to discuss accomodations or other special needs.