ASTR 519: Observational Astronomy
ASTR 719: Astronomical Data Reduction

Professor: Dr. Nicholas Law (nmlaw@physics.unc.edu)
Class Location: Phillips 247
Class Hours: Tuesday & Thursday, 12:30pm – 1:45pm
Lab Location: TBD
Lab Hours: TBD
Office Hours Location: 260 Phillips
Office Hours: 2pm-3pm Thursdays, or by appointment
Email: nmlaw@physics.unc.edu

LECTURES

The course is designed as an introduction to astronomical observing, with a focus on optical / infrared telescopes. The course is based on a practical approach to learning astronomical observing and data reduction, with hands-on experience. We will analyze existing astronomical datasets from large world-class observatories like UNC's SOAR. Every student will use the PROMPT array to observe several objects (including attempting to detect an exoplanet transit).

The course is divided into modules:

1) **Celestial Navigation:** locating objects in the sky & observing them with telescopes; position uncertainties and significant figures; introduction to Python & doing astronomy with Python; *planning an observing run.*
2) **Astronomical Imaging:** telescope optics; astronomical detectors; calibrating images; taking images with the PROMPT telescope array; signal and noise in images; *using Python for astronomical data reduction and making color images of galaxies.*
3) **The atmosphere & astronomy:** effects of the atmosphere including sky brightness & turbulence; methods of overcoming atmospheric turbulence including Adaptive Optics and Lucky Imaging; signal and noise in measurement; *building a Lucky Imaging analysis pipeline.*
4) **Calculating noise and uncertainty:** Noise and statistics; imaging with real detectors; evaluating and mitigating noise sources; designing astronomical surveys *(homework combined with module 5).*
5) **Getting telescope time:** designing an observing program; how to obtain telescope time; writing proposals *(making an exposure time calculator to optimize astronomical surveys; writing an observing proposal)*
6) **Precision astronomical measurement and running and observing program:** measuring the brightness of astronomical objects, astronomical bandpasses and colors, practical photometry with Python; detecting and removing systematic errors; *directly detecting exoplanet transits with PROMPT.*
7) **Spectroscopy, Bayesian statistics and Monte-Carlo error analysis:** spectrographs; spectral lines; spectral typing of stars; robust error analysis, *measuring redshifts and galaxy rotation curves*
8) **Multi-wavelength astronomy:** radio & X-ray telescopes; processing X-ray data; *making a movie of a pulsar jet.*
9) **Virtual observations of large surveys:** large astronomical surveys; astronomy with very large datasets; querying and cross-matching astronomical databases with SQL, discovering gravitational lenses in the Sloan Digital Sky Survey.

Each topic has an associated homework (the text in italics). The expectation is that each topic will take 3-5 lectures, although this will be adjusted during the semester as needed.

Textbook: There is no required textbook. If you would like to get one, I recommend "To Measure the Sky: an Introduction to Observational Astronomy" by Frederick Chromey; ISBN: 978-0521747684 or 978-1107572560.

In-class presentations: each class we will have a 5-minute presentation from a student about a recent observational astronomy paper selected from any of that week's releases on http://arxiv.org/archive/astro-ph. This assignment will rotate though the semester. Each ASTR 519 student will be expected to do one presentation; the remaining slots will be filled by the ASTR 719 students.

GRADES

Homeworks:	55%
Midterm:	20%
Final:	20%
Class participation:	5%

The participation grade will be based on participation in the class, in the lab time, and the in-class presentations.

Exams: the midterm and final are open book, open notes, but no internet-connected devices are allowed.

Homework collaboration policy: Collaboration to better understand the homeworks is encouraged, but *each student must do their own work and submit an independently prepared solution*. All the homeworks include programming challenges. You must submit both the results specified in the homework *and the code used to generate them*. The code will be run and tested with different inputs as part of the grading process, so make sure you follow the specifications in the homeworks. ***Copying code between students is not allowed, and will be checked for.***

Homework submission: Homeworks should be submitted using Sakai's dropbox feature, in a separate folder for each homework. To facilitate timely grading, unless prior arrangements have been made or there is a university-excused absence, *late problem sets will be accepted only up to the Monday after the due date (with a 20% penalty).* In the last few weeks of the semester you will have the opportunity to re-submit one problem set of your choice for re-grading.

Class attendance: Because there are several important in-class exercises, every class is required – let me know if you have to miss one.

Lab sessions: The lab sessions are designed to be office-hours-style tutorials to help you with the programming aspects of the course. Attendance is not required, but is **strongly recommended** as the programming challenges build on each other and ramp up quickly – **don't get left behind**!

Computing hardware and software: you will need a computer (any operating system) with 5+GB free disk space. All computing in this class will be done in Ubuntu Linux inside a VirtualBox environment – my experience is that this is by far the easiest setup for the type of computing done in this class, and has the added benefit of giving experience with a professional-style development environment. The first lab classes will cover setting this up on your computer. Most of the modules have one or two in-class exercises where you will also need your laptop.

CALENDAR

Lectures start Thursday January 12
No lectures March 14 & 16 (Spring break)
Midterm: Thursday March 9 (in class)
Last lecture: Thursday Apr. 27
Final exam: Friday May 5 @ 12pm

Homeworks will be due every two weeks, 6pm on Fridays (except for vacation interruptions).
The homeworks are due: Jan. 26, Feb 9., Feb. 23, Mar. 9, Mar. 30, Apr. 13, Apr. 27
(we may occasionally move back dates depending on how the class schedule goes).