

Observational Astronomy

ASTR 257, Fall 2025

Instructor: Andy Skemer

Office Hours: By appointment, plus TBD drop-in co-working sessions

Textbooks: None

Final Exam: None

Overview:

This class will give you an intensive, in person experience performing astronomical observations at Lick Observatory. Observing is a messy business! Weather and scheduling interfere with our experiments. Telescopes and instruments suffer from technical faults. Fatigue and monotony lead to human errors. At the same time, observing at a professional telescope is exciting and rewarding in a way that few people get to experience.

Over the course of a one-week field trip, we will learn to use a variety of techniques, such as astrometry, photometry, spectroscopy, and adaptive optics, while working with optical and infrared data. We will determine the distance to Pluto, measure the age of an open cluster, provide observational evidence for dark matter and monitor the cloud coverage on Neptune. As much as possible, the goal of this class is for you to learn observational astronomy through hands-on interaction with telescopes, instruments and astronomical data.

Students entering our program have different levels of experience with Python, observing and data reduction. I am committed to making this class work for all students, regardless of their previous experiences.

Learning Objectives:

- Students will learn to plan observational projects and execute them.
- Students will learn to manipulate and interpret raw astronomical data with standard tools and algorithms.
- Students will learn to present their observations in a standard written format that is appropriate for publication.
- Students will learn about observatory operations and career-paths.

Course Schedule:

The field trip to Lick will be Sept 20 - 26. During the rest of the quarter, there will be 1-2 additional scheduled classes (dates TBD). Lab writeups from the field trip will extend into the rest of the quarter. The class workload is designed to be complementary to ASTR 204.

Preparing for the Class

You will need a laptop to analyze data on the mountain. All first-year grad students get a research stipend which can be used to purchase a laptop if you do not already have one (contact Alyssa to access these funds). Most students in our program use Macbooks, but some choose PCs. You should be proficient at programming in Python. I will provide a Python tutorial, which you should complete in advance of the field trip.

Lick Observatory has dorm rooms with beds, blankets, towels and bathrooms, but you should bring everything else you need, including clothes and toiletries. There is no place to buy supplies once we are up there. It will be cool at night, so please bring warm clothes. We will carpool there and back.

I will bring food for the whole class. Please let me know about any dietary restrictions you might have.

Lick Observatory Projects (data to be collected during the field trip)

- 1) Use the Nickel telescope and its CCD imager to measure the proper motion of Pluto across multiple nights. Use these measurements to estimate the distance to Pluto.
- 2) Use the Nickel telescope and its CCD imager to obtain multi-wavelength photometry of an open cluster. Use the photometry to estimate to make an HR diagram and estimate the age of the cluster.
- 3) Use the Shane telescope and its KAST spectrograph to measure the rotation curve of an edge-on galaxy. Use the rotation curve to demonstrate the existence of dark matter.
- 4) Use the Shane telescope AO system and infrared camera to make a 3-color image of Neptune. Make an AO-on and AO-off version.

Other Projects (to be completed after the field trip):

- 5) Plan a JWST observation of a brown dwarf that achieves a specified signal-to-noise ratio
- 6) (Optional) Do an online ALMA tutorial for imaging the protoplanetary disk TW Hya.

Other activities to be completed during the field trip

- 1) Tour the facilities
- 2) Science in the Field training
- 3) Meet the mountain staff and discuss their jobs
- 4) Fill a dewar
- 5) Shadow a support astronomer as they set up
- 6) Shadow a telescope operator as they set up
- 7) Watch an instrument switch
- 8) Eyepiece observing with the 36" refractor
- 9) Visit the glass plate archive and historical instruments room
- 10) Close-up look at Shane-AO
- 11) Daytime lectures on:
 - Project descriptions
 - Astronomical coordinates
 - Basic CCD data reduction
 - Photometry
 - Signal-to-noise
 - Spectroscopy
 - Dithering
 - Adaptive optics
 - Lick history

After the field trip

1) Finish remaining items from the "Projects" list. Ideally, you got a good start on analyzing the data for the first four projects on the mountain. But people come into our program with different skillsets, and work at different speeds, and its fine if parts are completed later. Obviously completing the observations after leaving the mountain would be challenging.

2) For each project, write up the Observations and Reductions sections of an AJ-like paper. The *JWST* project writeup will more closely resemble the Technical Justification of a telescope proposal. I will provide a document with best-practices for these sorts of writeups.

Due Dates (11:59 PM Pacific)

Note: Andy will not be available to answer questions in the evenings of the due dates

Oct. 8—Pluto Lab Writeup
Oct. 22—HR Diagram Lab Writeup
Nov. 5—Dark Matter Lab Writeup
Nov. 19—Neptune Lab Writeup
Dec. 3—JWST Lab Writeup

Grades (A=90-100%, B=80-90%)

15% for each of the 5 projects writeups
25% for completing the “Other Activities”

I may have to re-weight these assignments based on weather and technical problems. If you adequately complete all of the writeups, you will pass the class with either an A or a B. If you do not adequately complete all of the writeups, you may request an incomplete, which I will only grant if there is a good cause for the incomplete (i.e. not just that you didn’t complete the work). For this class, incompletes must be resolved within 1 quarter. If your incomplete extends more than a few days, the highest grade you will be able to receive will be a B.

Students who complete *all* of their assignments on time will receive a special honor:
(<https://tinyurl.com/3bkxy78h>)

Expectations for Working in Groups

Planning and executing observations will be done in groups of 2-3. Data reduction and writeups will be done individually, although you should certainly compare your results and ask each other for help.

Expectations for Using Generative AI

It’s fine to use AI as a search tool or to help with your coding workflow. However, the basic algorithms you’re programming should be your own. The lab writeups should be written without using AI. If you have any questions about my expectations for AI, please ask.

Students with Disabilities

UC Santa Cruz is committed to creating an academic environment that supports its diverse student body. If you are a student with a disability who requires accommodations to achieve equal access in this course, please submit your Accommodation Authorization Letter from the Disability Resource Center (DRC) to me privately, preferably before the field trip. At this time, I would also like us to discuss ways we can ensure your full participation in the course. I encourage all students who may benefit from learning more about DRC services to contact DRC by phone at 831-459-2089 or by email at drc@ucsc.edu.

This class requires observational work at Lick Observatory, where many areas predate the Americans with Disabilities Act. I am committed to making classroom activities accessible to all students. Please contact me as soon as possible if you are concerned about mobility and accessibility so I can ensure that there are appropriate accommodations.

Sexual Harassment / Title IX

Title IX prohibits gender discrimination, including sexual harassment, domestic and dating violence, sexual assault, and stalking. If you have experienced sexual harassment or sexual violence, you can receive confidential support and advocacy at the Campus Advocacy Resources & Education (CARE) Office by calling (831) 502-2273. In addition, Counseling & Psychological

Services (CAPS) can provide confidential, counseling support, (831) 459-2628. You can also report gender discrimination directly to the University's Title IX Office, (831) 459-2462. Reports to law enforcement can be made to UCPD, (831) 459-2231 ext. 1. For emergencies call 911.

Please note that I am a mandatory reporter, which means that I am required to report Title IX violations to the Title IX office, even if the person who tells me wishes the information to be confidential.

Safety and Personal Conduct

Observatories can be dangerous. In the interest of safety, please follow all directions from Lick Observatory staff. Also, please make sure your interactions with one another are respectful, professional and inclusive. It is very important to us that this class is a safe and inclusive learning environment for all participants.