

Modern Astronomical Techniques

ASTR 257, Fall 2019

Instructor: Andy Skemer (lead) and Xavier Prochaska

Office Hours: Drop by Andy's office, or schedule appointment

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.

This course will serve as a kickoff to your education in the UCSC Astronomy & Astrophysics Ph.D. program. 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 21 - 27. During the rest of the quarter, there will not be scheduled classes, but some work 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. 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 if you feel that you need practice with Python.

Lick Observatory has dorm rooms with beds, blankets, and bathrooms, but you should bring everything else you need, including clothes, toiletries, and a towel. 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 remind me of any dietary restrictions you might have. If you want to come on the Costco run with me before we leave, let me know.

Projects (to be completed or mostly completed 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.

Projects (to be completed after the field trip):

- 5) Plan a JWST observation of a brown dwarf that achieves $S/N > 10$ from 3-5 microns.
- 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) Fill a dewar
- 3) Shadow a support astronomer as they set up
- 4) Shadow a telescope operator as they set up
- 5) Watch an instrument switch
- 6) Eyepiece observing with the 36" refractor
- 7) Daytime lectures on:
 - Project descriptions
 - Astronomical coordinates
 - Basic CCD data reduction
 - Photometry
 - Signal-to-noise
 - Spectroscopy
 - Radio Astronomy
 - Adaptive optics

After the field trip

1) Finish any remaining items from the "Projects" list. Ideally, you completed the four field trip projects on the mountain. But people come into our program with different skillsets, and work at different speeds, and its fine if a few items are completed later. Obviously completing the observations after leaving the mountain would be challenging.

2) For each project, write up the Observations and (when relevant) Reductions sections of an AJ-like paper. The *JWST* project writeup will more closely resemble the Technical Justification of a telescope proposal.

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

15% for each of the 5 projects (including writeups)

25% for completing the "Other Activities"

I may have to re-weight these assignments based on weather and technical problems. If you complete all of the assignments and writeups, you will pass the class with either an A or a B. If you do not complete all of the projects and writeups, you will receive an Incomplete which can be resolved by completing the projects and writeups.

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.

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 me that this class is a safe and inclusive learning environment for all participants.