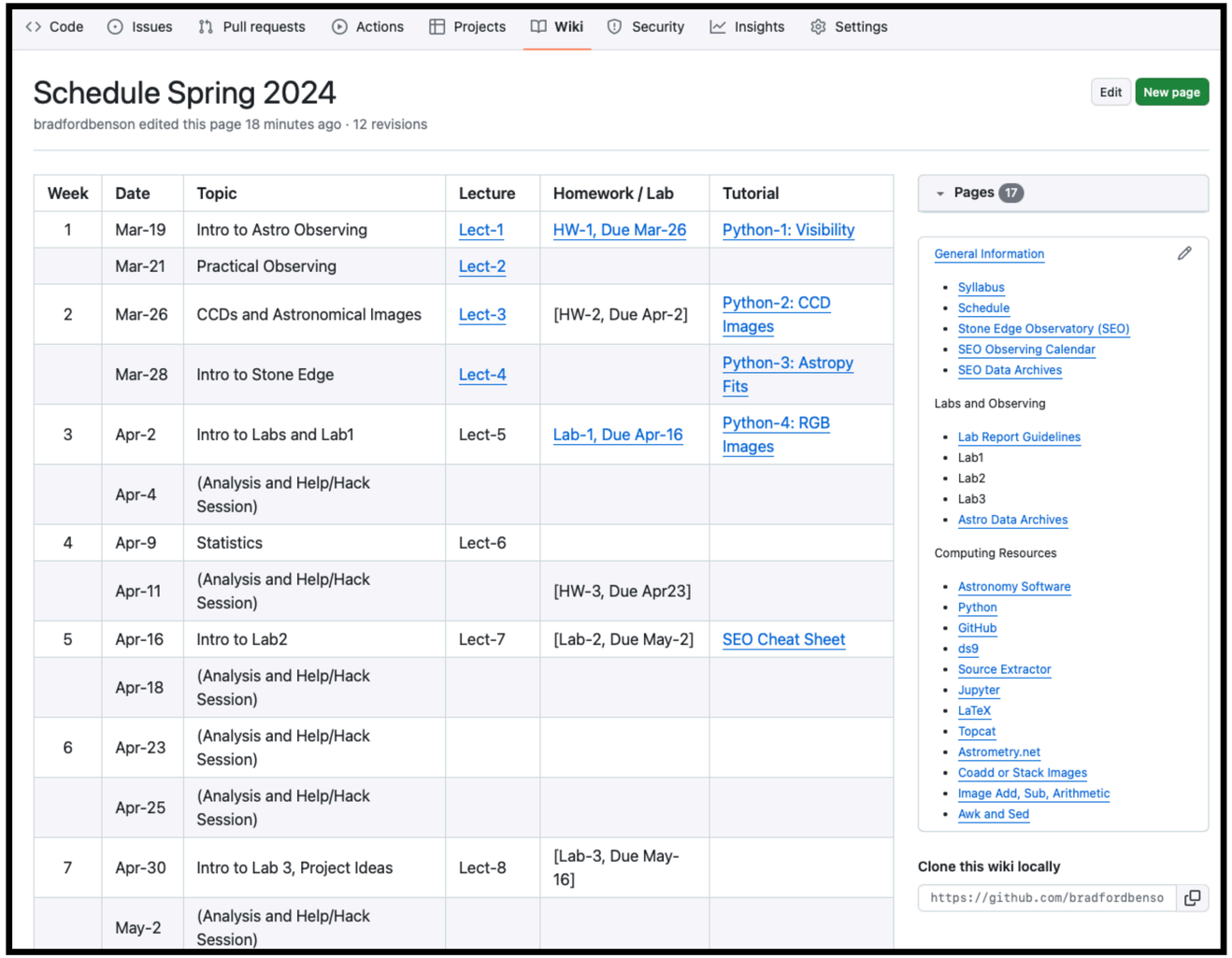
ASTR21200

Observational Techniques in Astrophysics
Lecture 5

Bradford Benson

Lab-1: Properties of CCDs and Astronomical Images

- Brief intro for context for the lab!
- Lab is posted on the GitHub and Canvas
  - (As of March-28): Last years lab is posted, but I will update it ahead of next week's class
- Three phases to the lab:
  1) Analyzing "archival" SEO data
  2) Scheduling and analyzing SEO data of your own
  3) Take observations on the roof of ERC with Rohan and Dillon (weather permitting)



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Schedule Spring 2024

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bradfordbenson edited this page 18 minutes ago · 12 revisions

Week	Date	Topic	Lecture	Homework / Lab	Tutorial
1	Mar-19	Intro to Astro Observing	Lect-1	HW-1, Due Mar-26	Python-1: Visibility
	Mar-21	Practical Observing	Lect-2		
2	Mar-26	CCDs and Astronomical Images	Lect-3	[HW-2, Due Apr-2]	Python-2: CCD Images
	Mar-28	Intro to Stone Edge	Lect-4		Python-3: Astropy Fits
3	Apr-2	Intro to Labs and Lab1	Lect-5	Lab-1, Due Apr-16	Python-4: RGB Images
	Apr-4	(Analysis and Help/Hack Session)			
4	Apr-9	Statistics	Lect-6		
	Apr-11	(Analysis and Help/Hack Session)		[HW-3, Due Apr23]	
5	Apr-16	Intro to Lab2	Lect-7	[Lab-2, Due May-2]	SEO Cheat Sheet
	Apr-18	(Analysis and Help/Hack Session)			
6	Apr-23	(Analysis and Help/Hack Session)			
	Apr-25	(Analysis and Help/Hack Session)			
7	Apr-30	Intro to Lab 3, Project Ideas	Lect-8	[Lab-3, Due May-16]	
	May-2	(Analysis and Help/Hack Session)			

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General Information

- Syllabus
- Schedule
- Stone Edge Observatory (SEO)
- SEO Observing Calendar
- SEO Data Archives

Labs and Observing

- Lab Report Guidelines
- Lab1
- Lab2
- Lab3
- Astro Data Archives

Computing Resources

- Astronomy Software
- Python
- GitHub
- ds9
- Source Extractor
- Jupyter
- LaTeX
- Topcat
- Astrometry.net
- Coadd or Stack Images
- Image Add, Sub, Arithmetic
- Awk and Sed

Clone this wiki locally

https://github.com/bradfordbenso

Lab-1: Overview

2 Data and Observations

We will start by looking at archival data from the SEO database. To do this, we fill follow these basic steps: a) find an image in the SEO database , b) characterize the properties of the image, before and after calibration, c) characterize the properties of the calibration frames, and d) make a plan for future observations with SEO later in the week.

2.1 SEO Observations

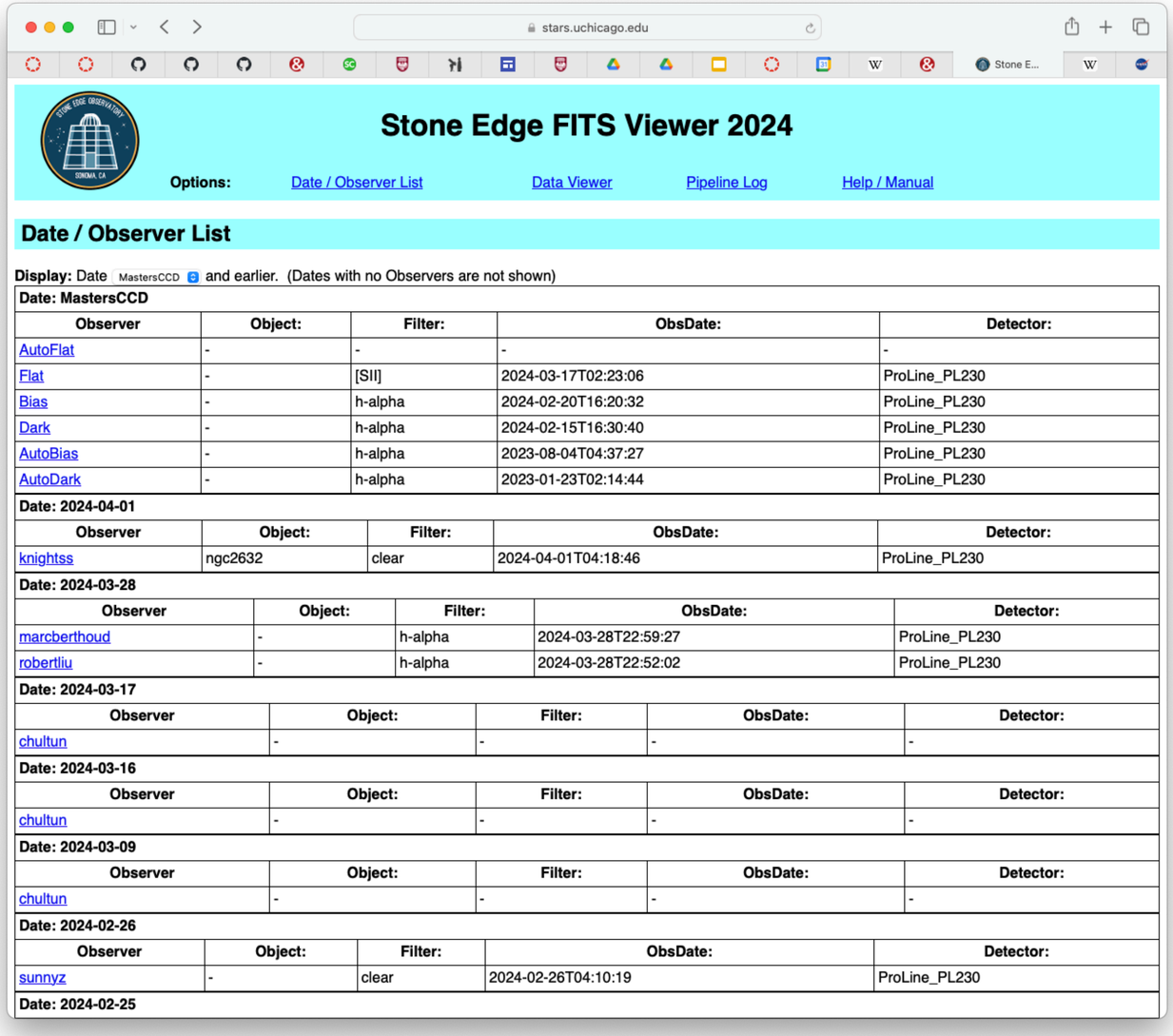
For step (a), follow these steps:

1. Go to the SEO FITS viewer website: *https://stars.uchicago.edu/fitsview24/*.
2. Find a recent observation (i.e, past ~3-months) that looks interesting to you.
3. Download both the *Raw* and *Flux Calibrated* image, which will be noted in the *Pipe Step* button. The raw and calibrated FITS file should say *RAW* and *FCAL* in the name, meaning that the processing pipeline has calibrated this observation (i.e., correcting for bias, dark, flat fielding).
4. In the FITS header, find the names of the files used for the: bias, dark, and flat-fielding. Download these FITS files.

For your lab report, you will want to:

1. Describe the object you choose, i.e., What is it? A planet, a galaxy, a nebula, etc.?
2. Describe basic properties of the observations, e.g.., When were they taken? What filter bands were used? How long was the exposure?
3. In a Table, give the directory location and names of each file that you used.
4. Make a Figure (or Figures) that shows images for each of these files: a) Raw image, b) Calibrated image, c) Bias frame, d) Dark frame, e) Flat-field.

Use SEO FITS archive to find data



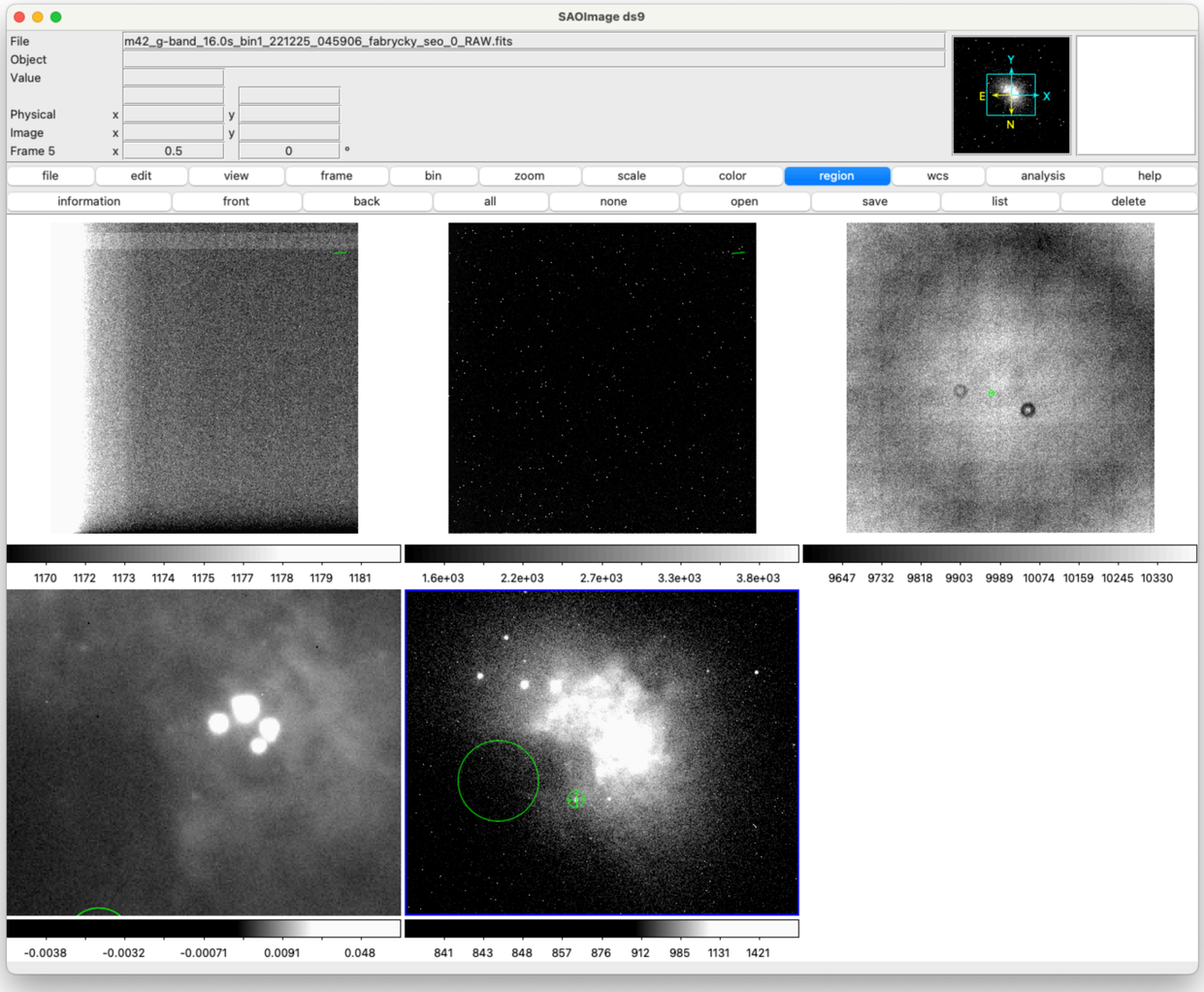
Lab-1: Overview

3 Data Analysis

For each of the observations above, characterize the basic statistical properties of the images and include the below information in your lab report:

1. For each image, measure the mean, median, standard deviation, maximum, and minimum value of the images. Put these values in a table, and describe the basic properties of each, i.e., why they do (or don't) make sense given the nature of each (e.g., why are the calibrated units different than the raw image? How do the mean and standard deviation of the bias compare to the other images?
2. **Bias frame:** The standard deviation of the bias frame is a measure of the read noise in units of counts. Does the standard deviation match the width of the distribution in the histogram? Why doesn't it? What might be a better way to estimate the read noise (i.e., rather than a straight standard deviation)?
3. **Dark frame:** Plot a histogram of the counts. Can you identify any hot pixels? From the histogram, what cut would you use to reject them? And what fraction of pixels gets rejected?
4. **Dark frame:** What is the dark current in electrons per pixel per second? What temperature was your dark frame taken at? Was the bias frame taken at the same temperature, and how would that affect this measurement?
5. **Flat field:** Plot a histogram of counts in the flat field? Describe its statistical properties, and relate features in the image to what you see? What does the flat field have to say quantitatively about the variation of sensitivity or efficiency across the raw image?
6. **Calibrated Image:** Choose a region of the image where there are one (or several) obvious astronomical objects. Can you fit a Gaussian to the point spread function (PSF) and measure the full-width at half-maximum (FWHM)? What is your measured FWHM in pixels? and arcseconds?

To plot and analyze data, most likely use ds9, python (see tutorial on wiki), or other programs of your choice



Lab-1: Overview

ASTR 21200: Observational Techniques in Astrophysics

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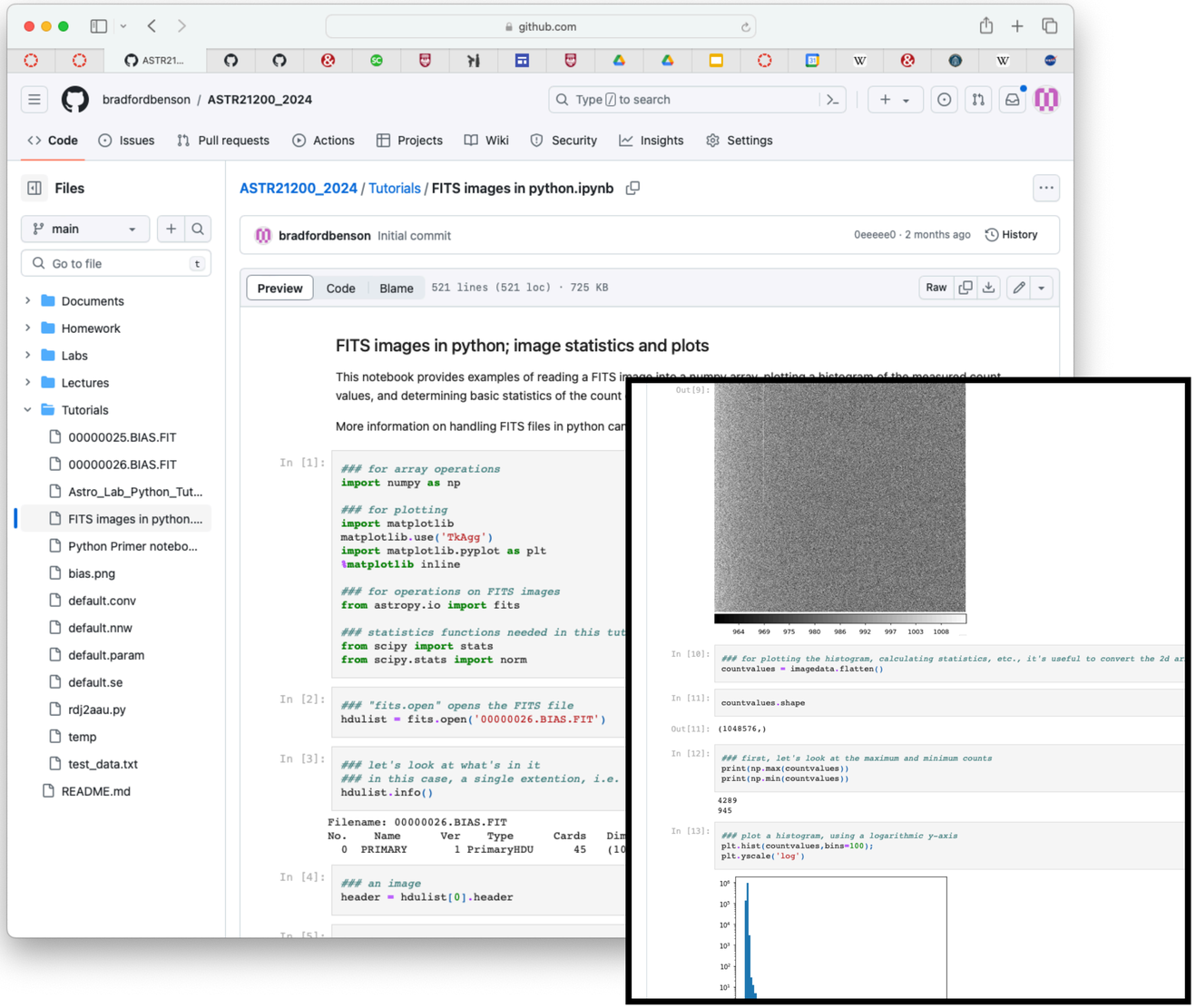


Lab-1: Overview

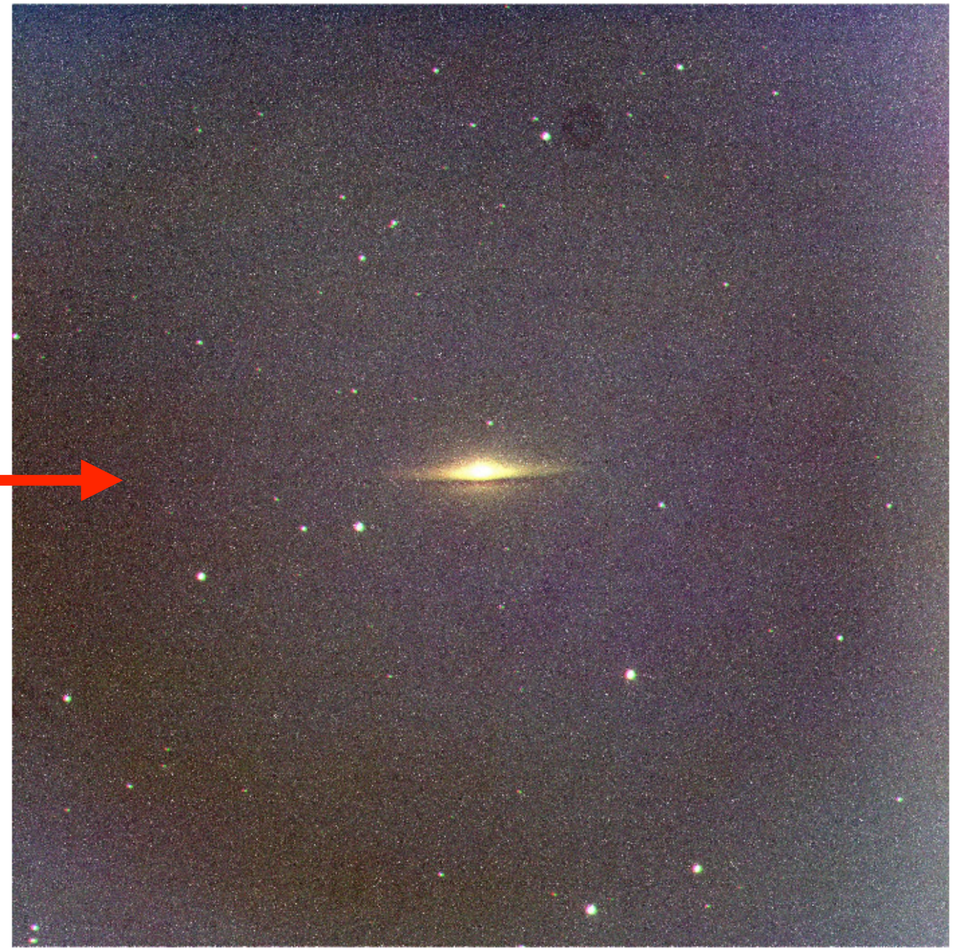
Take an observation with SEO and make an RGB image

4 New SEO Observations

To gain experience with real-time observations with SEO, you are going to take an image of an object from the *Messier catalog*. The Messier catalog includes some of the most visually impressive objects in the sky. There were originally selected in the 18th century as a set of relatively bright, extended, non-stellar objects. There are 110 Messier objects in total, and includes 39 galaxies, 29 globular clusters, 27 open clusters, 6 diffuse nebulae, 4 planetary nebulae, and 1 supernova remanent. You can find a full list of Messier objects at *https://en.wikipedia.org/wiki/Messier_object*.

Preparing for your SEO observations:

1. *Join Itzamna:* Make sure you are in join the **itzamna** channel on the SEO Slack. Ask your TAs, Brad, or Marc to be invited.
2. *Pick an object:* Look through the list of Messier objects, and find one that is interesting to you and observable from SEO in the next week. Feel free to use itzamna channel to find objects and plot their visibility.
3. *Schedule a time:* Make sure to check out the SEO calendar [1]. Pick a date and time that would be convenient for your group to observe your targets and reserve time on the calendar. Ideally, you would schedule a zoom session amongst your lab group to jointly participate and follow along with remote observing.
4. *Itzamna observing instructions:* For detailed observing instructions, review and follow the steps in the *SEO Cheat Sheet* [2]
5. *Take SEO images:* Take *gri* filter measurements of your object (i.e., one observation per filter, three observations total). You will likely want to take 30 or 120 second exposures, though it will depend on the object's magnitude. You might want to take an initial short exposure (e.g., 10 or 30-sec), to see how it looks before deciding.
6. *Download your data:* You will likely have to wait 1-day for your images to be processed. You can check on the processing state and eventually download your data



Lab-1: Overview

Weather permitting, we will schedule an observing night(s) on ERC rooftop next week

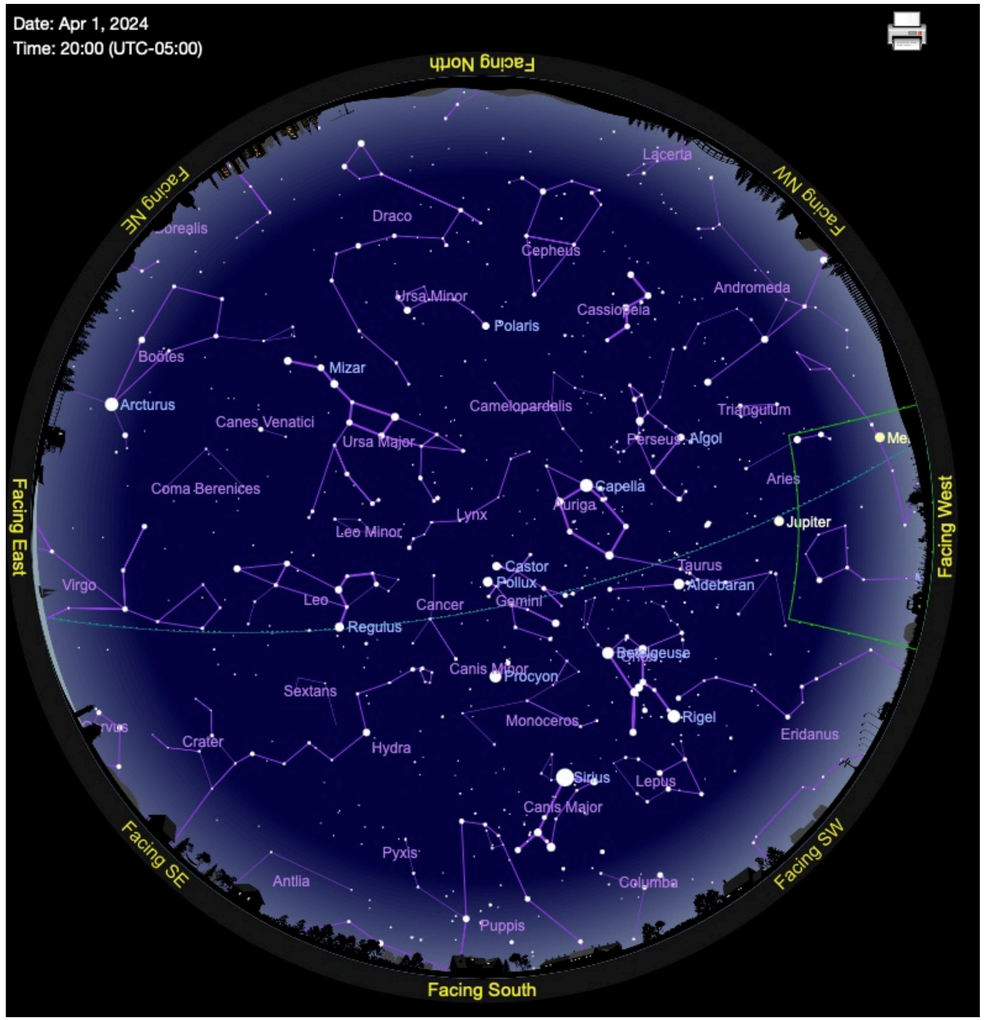
5 Rooftop Observing

Weather permitting (we will discuss more in class) with your TAs (Dillon and Rohan) on one of two designated nights on the 5th floor deck of the Eckhardt Research Center (ERC 501)[5]. With them you are going to use a small telescope on the roof, find an object with it, and take an image.

1. *Pick an object:*. See Figure 1 for possible options. Feel free to update the star chart for your particular time and day. Early in the night, you can see some potential options, such as Jupiter in the East. And bright stars like Arcturus, Sirius, Betelgeuse, and the North Star (Polaris).
2. *Find your object:* Use the telescope and try to find your object with the telescope. Are there any physical obstructions preventing you from seeing the object? What are they? If yes, you might want to pick a different object.
3. *Take an image:* Take an image of your object with the camera on the telescope. **Save the image and include it in your Lab Report.**

For your lab report, you will want to:

1. Describe the object you choose, i.e., What is it? Is it a planet, a galaxy, a nebula, a star, etc.?
2. Were there any physical obstructions preventing you from seeing the object? What are they?
3. Were you able to see your object? Why or why not?
4. Save the image and include it in your Lab Report.



Lab-1: Overview

- Lab-1 instructions include guidance about what format we want for the Lab Report.
  - Expecting the first report to be in Jupyter notebook form, with outline mirroring the Lab instructions (i.e., Intro, Data/Observations, Data Analysis, Future Work) (similar to a paper)
- ***Each person should submit their own Lab report!***
  - Common analyses / code / images can be used by the lab group, but each individual should write their own lab report, with descriptions and text of their own).

6 Lab Report

Prepare a *jupyter* notebook that documents your entire analysis for the lab. Make sure to explain your steps and conclusions; imagine writing a tutorial for another astronomy student, who is not taking the class. Use *markdown* boxes (which can also parse LaTeX). Note that you can also include figures (i.e., in png, jpg, etc. form) that are produced outside of the notebook (e.g. with ds9).

The explanations in the *jupyter* notebook will be what we read, but we might look at your code if we think you did something wrong. Make sure that the report is logical; each section should have a short introduction, then code with results and plots, then a conclusion. Make sure the section numbering follows this manual (e.g., Introduction, Data, Data Analysis, Conclusions). Once your notebook is finished, make sure to restart it and re-run all cells. Then save the notebook in pdf format, e.g., through the print menu.

Lab-1: Lab Groups

- Your will do the labs in “groups”
  - We have 29 people in the course, we will need to break into 6-7x groups of 3-5 people per group
  - Feel free to choose your group, and we will help match anyone needing a group.
- Any questions?

6 Lab Report

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