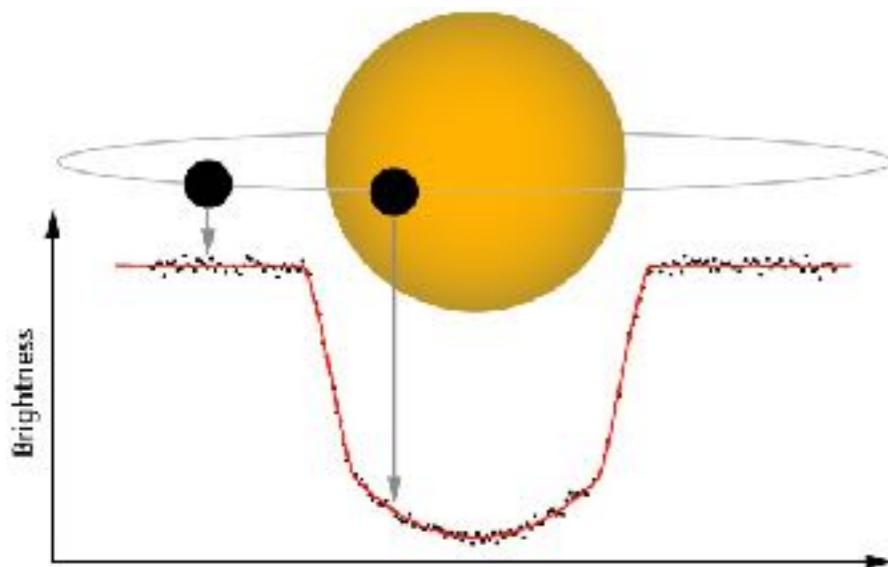
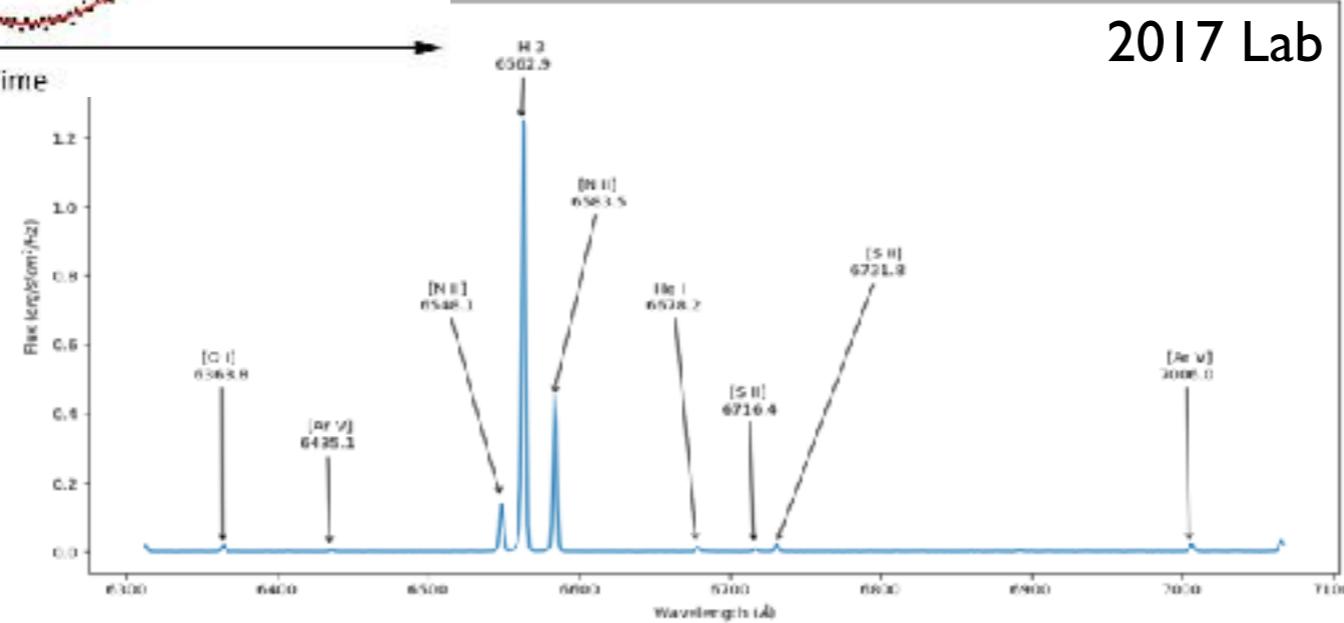


PHY 517 / AST 443: Observational Techniques in Astronomy

Simon Birrer



ESO



Spring 2024

SBU
Astro
Club



2017 Lab



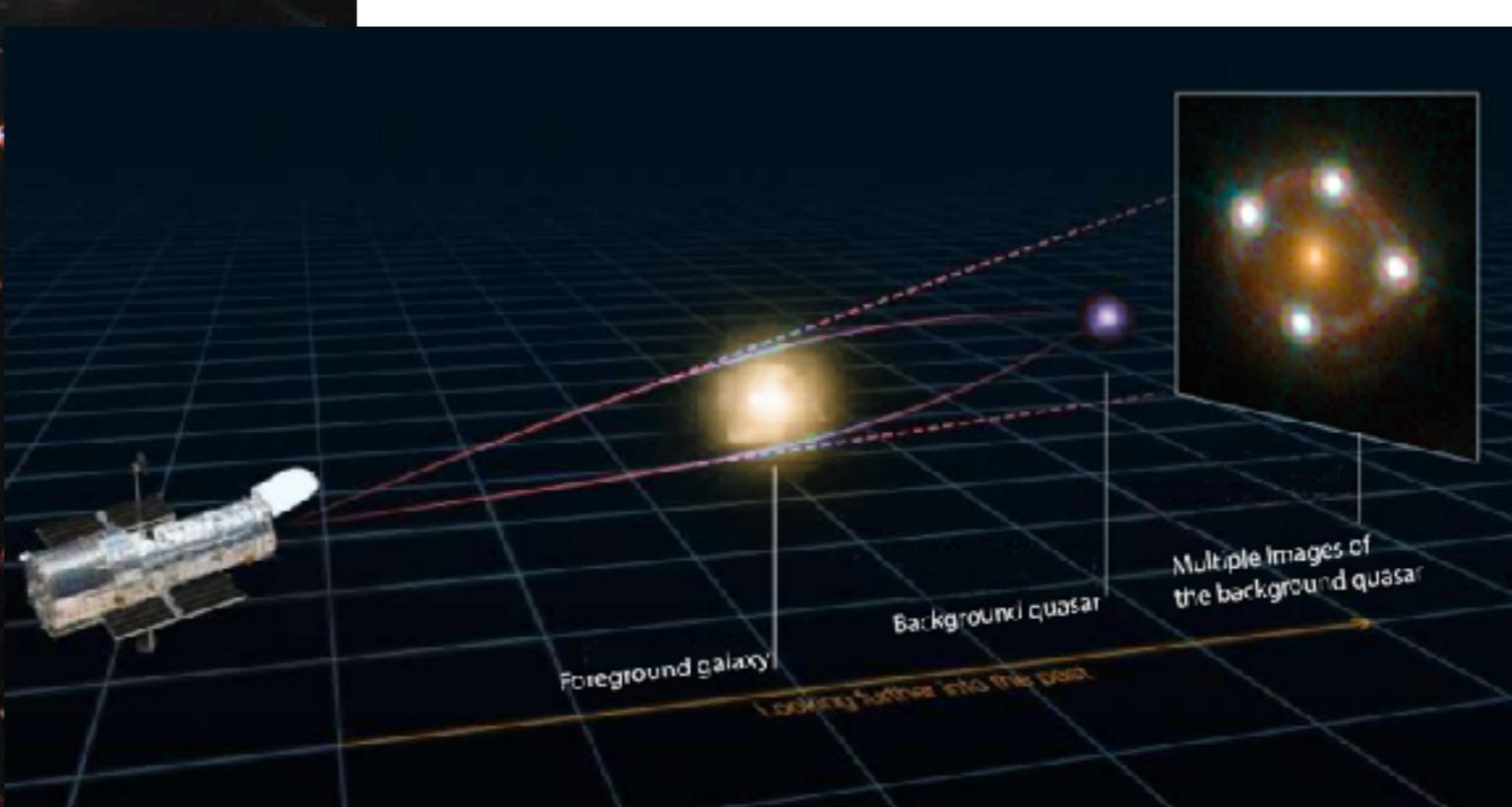
AvdL



Hello!

I am an observational cosmologist using strong gravitational lensing to learn about dark matter and dark energy.

NASA





ETH Zurich

My Bio



UCLA

undergrad:

ETH Zurich (exchange in Hong Kong)

PhD:

ETH Zurich 2013 - 2016

post-docs:

University of California, Los Angeles 2017 - 2019

Stanford University 2019 - 2022

since Jan. 2023: faculty at SBU



Stanford



Stony Brook

Big questions - big data!

Astronomy and Cosmology are data driven!



Cerro Tololo, Chile, 2014

My advisor: “Simon, touch the data!”



Strong Lensing Group, Spring 2023

Course TAs

Ben Levine

<benjamin.c.levine@stonybrook.edu>

Zhi Chen

<zhi.chen.3@stonybrook.edu>

Course Purpose

- graduate-level class (PHY 517), cross-listed for advanced undergraduates (AST 443) planning to go to grad school for astronomy
- purpose:
 - teach you the basics of how to be an observational astronomer*
 - research practices (collecting data -> making a scientific statement)

*this is the *only* class at SBU with this purpose: we have a lot to cover

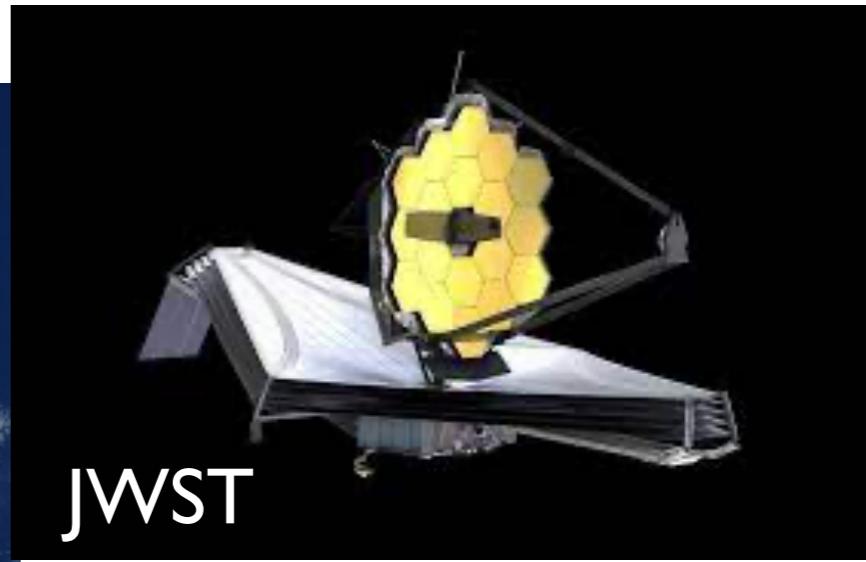
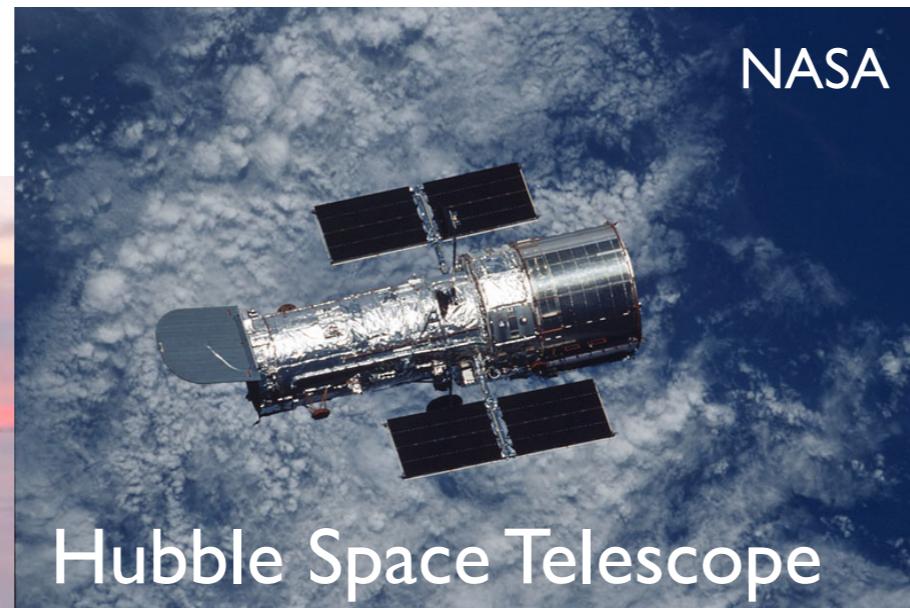
Course Objectives

- introduction to observational astronomy
- design, take, analyze and interpret astronomical observations
- report your work in a scientific paper
- same concepts as needed for these:

A. Cooper



Keck 10m telescopes



Mt Stony Brook Observatory

- roof-top dome + telescope (14-inch) + CCD camera + spectrograph



SBU Astronomy Club

How to be an observational astronomer

1. come up with an interesting idea / hypothesis
2. search for and analyze archival observations
3. write a **telescope proposal**
4. plan and execute your **observations**
5. analyze your **data**
6. write a **journal paper**
7. present your work at conferences

We'll deviate a bit ...

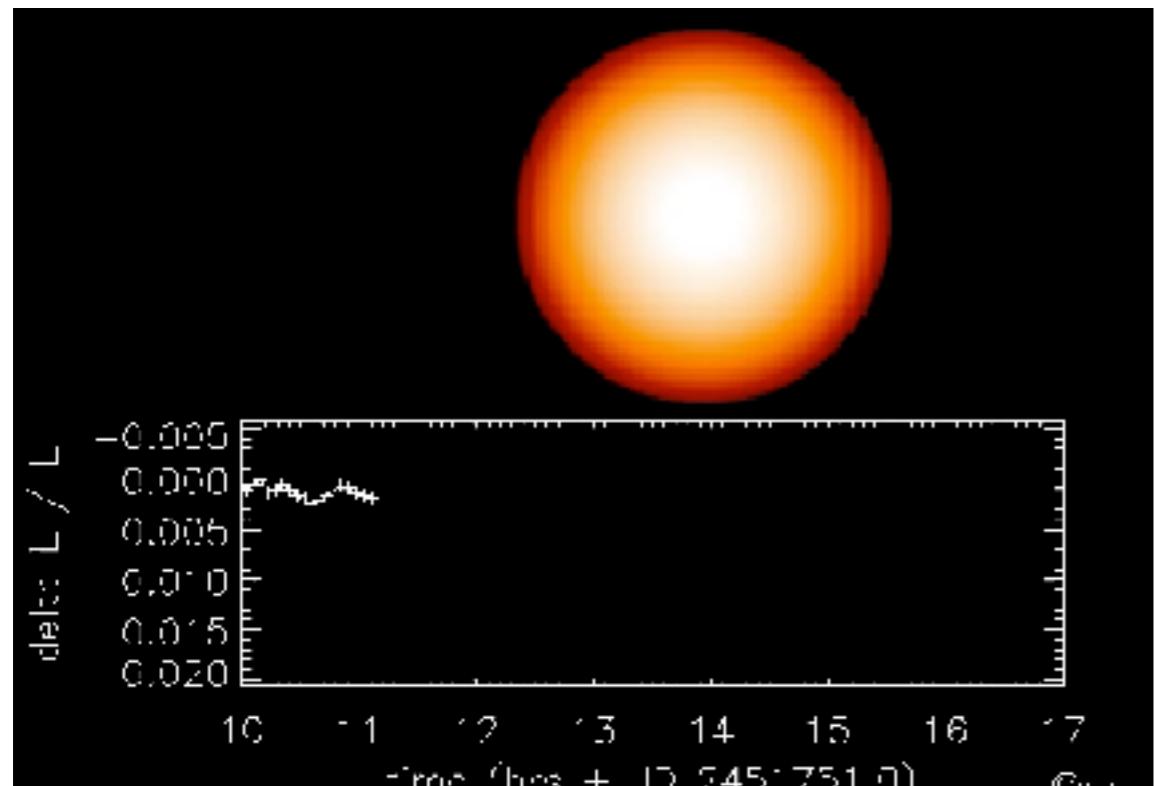
1. conduct and analyze **observations**
2. lab report → **journal paper**
3. write a **telescope proposal**
4. serve on a Time Allocation Committee (TAC)
5. **present your work in class**

Lab 1 - CCD cameras and images

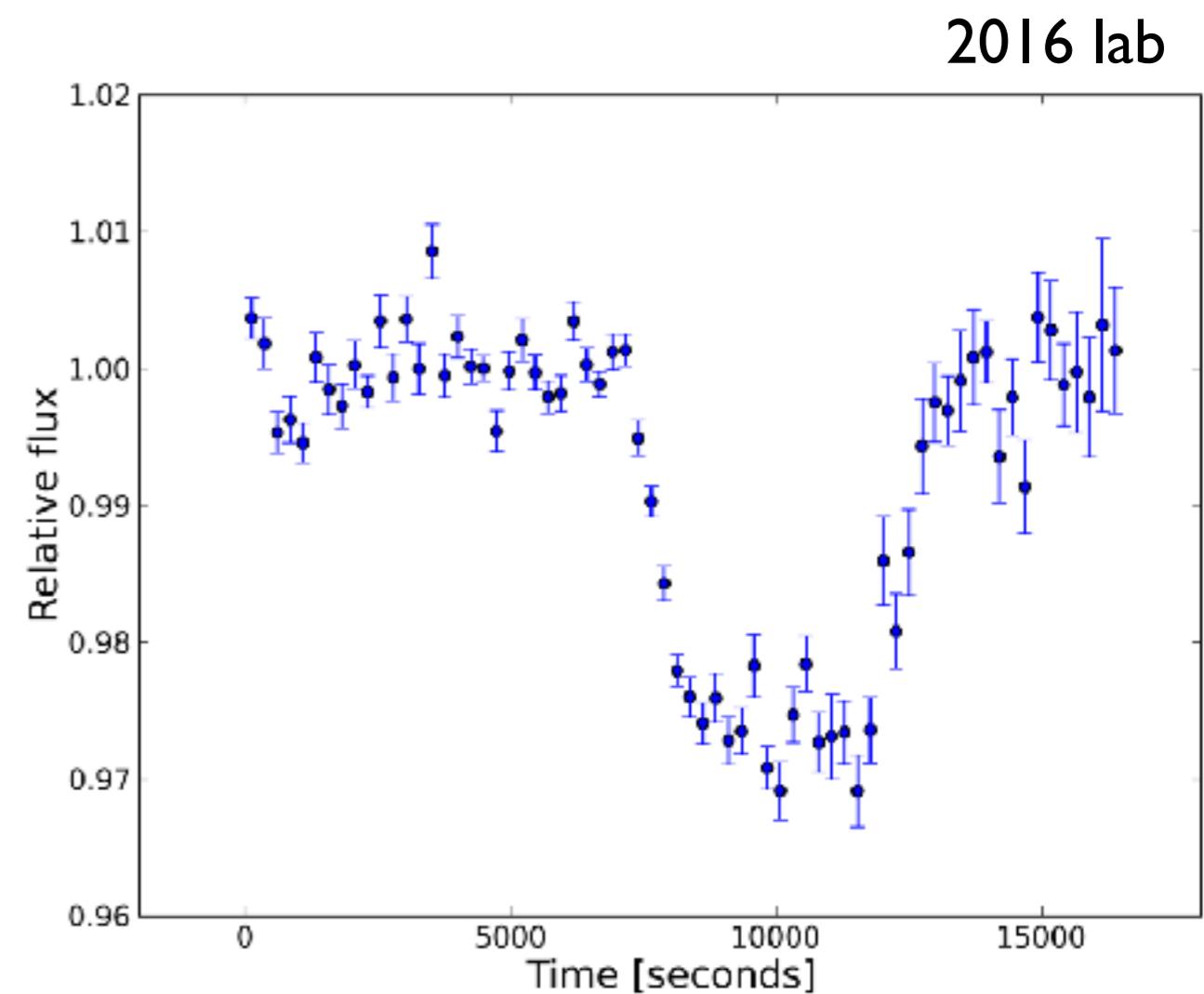
- measure properties of our CCD cameras
- understand the role of calibration data
- familiarize yourself with the equipment
- make a pretty image of an interesting astronomical object

Lab 2.1 - optical imaging; time-series photometry

- detect an exoplanet transit

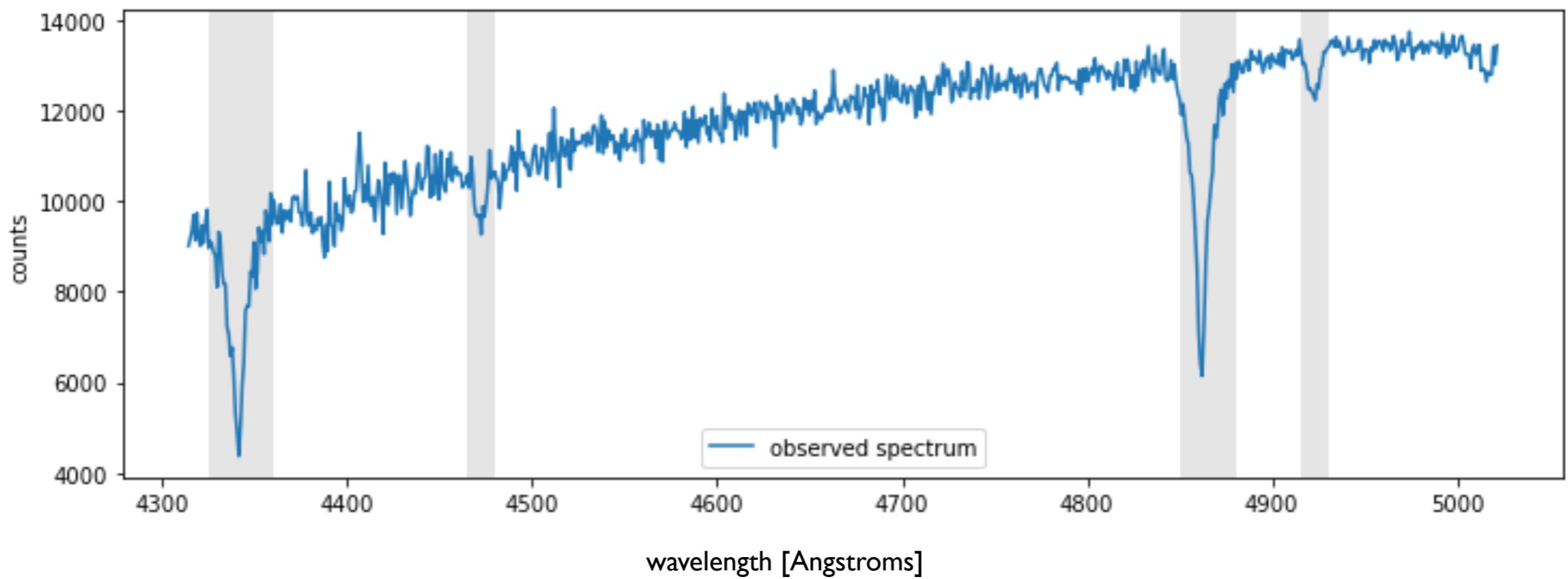


Deeg & Garrido 2000



Lab 2.2- optical spectroscopy

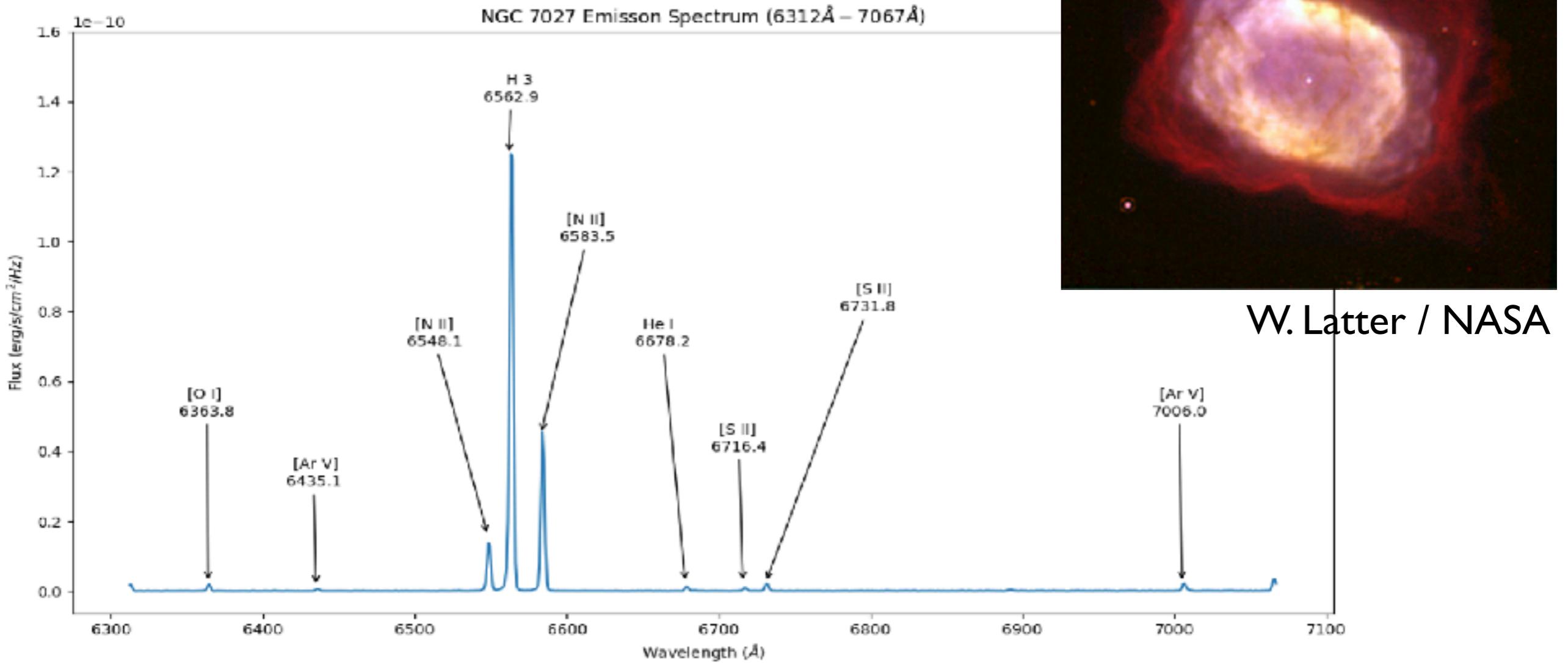
- compare spectra of stars with range of temperatures



Lab 2.2 - optical spectroscopy

- OR: measure the gas temperature of a gaseous nebula

2017 lab



Lab 3 - your proposal

- come up with your own project idea, write a telescope proposal for the Mt. Stony Brook telescope
- we will hold a Time Allocation Committee - just like real astronomers!
- each lab team will conduct their top-ranked project

Have some fun pursuing your own ideas!

Data analysis

astronomy ~100 years ago:



astronomy today:

F. Patat

Mt. Wilson archive

Data analysis

- CCD cameras and digital image processing were revolutionary for astronomy
- first CCD cameras used on telescopes ~1980
- the Sloan Digital Sky Survey (SDSS), designed in the 90s, was one of the first “Big Data” projects; today we are preparing for the Rubin Observatory’s Legacy Survey of Space and Time (LSST), ~20 TB per night, every night for 10 years
- *research in astronomy requires programming, and statistical analysis of large datasets*

- we will use several common astronomy software packages:
 - Photutils
 - Source Extractor
 - ds9
 - astrometry.net
 - FTOOLS
- most astronomy research is done on Unix / Linux. bash provides an integrated scripting language
- python is becoming ubiquitous in astronomy as higher-level programming language
- however, this is not a class on programming. we will provide basic instructions and help, but you will have to figure out many things on your own (search engines are your friend!)

Computing Resources

- all necessary software is installed on two machines in the Astro Computing Lab (uhura and vulcan)
- you can work in the Lab, and/or you can **ssh** into these machines from your laptop
- you will receive a username and password (valid for all computers in the lab); please change your password - make it complex!
- **keep your password safe!** our computers are under constant attack
- **back up your data!** e.g. google drive. minimum: your raw data, scripts to analyze the data, data that you used for final plots

Class structure

Class times:

- Mon + Wed 2:30-5:30pm
- ~6 lectures in the beginning
- other sessions: tutorials / data analysis help sessions with interludes
- Proposal deadline: Mar. 8
- Time Allocation Committee: Mar. 19
- Final Presentations: Apr 29 + May 1

Class structure

Data taking:

- scheduled **separately from class time**
- Lab 1: evening-time
- Labs 2+3 - observational labs: **evenings / nights**; you need good weather → schedule target night + 2 backup nights for each lab

It is essential that you get your data - you will need to be flexible about scheduling night-time observations!

Course webpage:

https://github.com/sibirrer/PHY517_AST443/wiki

sibirrer / **PHY517_AST443**

Type to search

Code Pull requests Discussions Actions Projects Wiki Security Insights Settings

Home

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Edit **New page**

General Information

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Instructor: Simon Birrer (simon.birrer 'at' stony brook.edu, ESS 457-A)

Office hours (TBD):

- Tue TBD (ESS 450, Ben Levine)
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- Fri TBD (ESS 450, Zhi Chen)

TAs:

- Ben Levine (benjamin.c.levine 'at' stonybrook.edu), office hours Tue TBD, ESS 450 or by appointment
- Zhi Chen (zhi.chen.3 'at' stonybrook.edu), office hours Fri TBD, ESS 450 or by appointment

Suggested texts:

- Measuring the Universe, G. Rieke (Cambridge University Press, 2012)

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Schedule Spring 2024

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[Edit](#) [New page](#)

Date	Topics	Slides	Tutorials	Homework
Jan 22	Intro, Coordinate Systems	Lecture 0 , Lecture 1		HW1, due Jan 29
Jan 24	Time, Magnitudes, Atmosphere, Telescopes	Lecture 2		HW2, due Jan 31
Jan 29	CCDs, FITS files	Lecture 3	Python1 , Python2	
Jan 31	Statistics 1	Lecture 4		HW3, due Feb 07
Feb 05	Statistics 2	Lecture 5	Tu4	HW4, due Sep. 19
Feb 07	Spectroscopy	Lecture 6		
Feb 12	Data Analysis Help Session			
Feb 14	Instructions: Proposal Writing	Lecture 7 , wiki link		
Feb 19	Data Analysis Help Session		TU5	
Feb	Data Analysis Help Session			

Lecture notes, etc. will
be linked from schedule

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Observing Equipment

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Mt. Stony Brook 14-inch telescope

Our Department operates the Mt. Stony Brook observatory, housing a 14-inch Meade LX200-ACF telescope on a Mesu-200 German Equatorial Mount. This will be the workhorse telescope for the imaging and spectroscopic components of the course.

Step-by-step instructions

[Telescope manual](#)

[Mesu mount Set-Up Instructions](#)

[SiTech Controller Manual](#)

The mount has GoTo functionality through the software [Cartes du Ciel](#).

CCD camera for imaging

Imaging observations with the 14-inch telescope will be taken with the SBIG STL-1001E CCD camera. The CCD camera is mounted on the back end of the telescope and is controlled through a laptop computer. A set of standard broad-band BVRI and a narrow-band H-alpha filters are available.

[STL-1001E spec sheet](#)

CCDSof t step-by-step instructions

[Operations manual](#)

[CCDSof t manual](#)

Spectrographs

We have two DADOS spectrographs; one has the low-resolution grating (200 l/mm) installed, the other the high-resolution grating (900 l/mm).

Manuals etc. for all observing equipment

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Observing Calendar

Observing Calendar

[Edit](#)[New page](#)

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The observing calendar be found [here](#).

Mt Stony Brook Observing Calendar

Today [◀](#) [▶](#) September 2022

[Print](#)[Week](#)[Month](#)[Agenda](#)

Events shown in time zone: Eastern Time - New York

+ Google Calendar

Mon	Tue	Wed	Thu	Fri	Sat	Sun
29	30	31	Sep 1 7pm Open Night	2	3	4
5 Labor day - no class	6	7	8 No observing	9	10	11 Full Moon
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	Oct 1	2

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CCD Lab

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Lab Instructions

Edit

New page

Experiment Description:

https://github.com/sibirrer/PHY517_AST443/blob/main/ccd_lab/ccd_lab.pdf

Equipment Quick-Start Instructions:

[Telescope](#)

[CCDSof](#)

[Spectrograph](#)

Preparation:

Schedule your data acquisition with the TAs. The lab takes about 3-4h. **Make sure to read and understand ALL instructions linked above before the lab!** You will be quizzed on the concepts that the lab conveys.

Moreover, good preparation will allow you to complete the lab faster. *If you are not adequately prepared, you will have to reschedule the lab, and will receive a grade penalty.*

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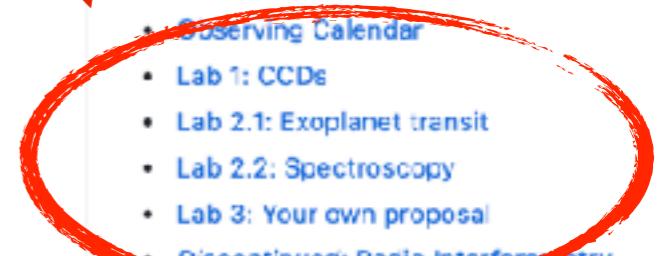
▶ Pages (31)

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Computing Resources

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Astro Computing Cluster Instructions

The Astro Student Computing Lab

Data analysis sessions and tutorials will take place in the Astro Computing Lab in ESS.

You will receive an envelope with your username and password to these computers at the beginning of the course.

The machines should have all needed astronomy software installed (except python software that can be installed later).

In addition, `kirk` is the central server. Note that this machine is not physically accessible. You can also choose to bring your own laptop to connect to the machines in the Astro Computing Lab instead (see instructions below).

There are enough computers so that every group can use one, but not enough for all students, so please bring your own laptop if you have one.

The computers in the Astro Computing Lab all run Linux, with which you should be familiar from PHY 277.

If you are a bit rusty on your Linux command line skills, you may find a "cheat sheet" such as [this one](#) useful.

Your log-in

You will receive either an e-mail, or a sheet of paper with your username and initial password. **Do not give this password to anybody else, or leave it lying around.**

With this account, you can log into any computer in the computing lab, directly or remotely (remote access is described below). Your first action should be to change your password (see below).

When using the astro lab computers in person

The fastest (and recommended) desktop manager on our systems is `MATE`.

To select it, click on the settings wheel on the screen where you enter your password. Please make sure to log out when you are done! Do not just leave the computer with the screen locked.

Do not restart the computer!

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- [Python](#)
- [jupyter](#)
- [GitHub](#)
- [ds9](#)
- [SExtractor](#)
- [Topcat](#)
- [Astrometry.net](#)
- [Image arithmetic \(+ftools\)](#)
- [Stacking images](#)

Specific
software
descriptions

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Homework reading until next week

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Suggested texts:

- Measuring the Universe, G. Rieke (Cambridge University Press, 2012)
- Data Reduction and Error Analysis for the Physical Sciences, P.R. Bevington & D. K. Robinson (McGraw-Hill Higher Education, 2003)
- Practical Statistics for Astronomers, J.V. Wall & C.R. Jenkins (Cambridge University Press, 2008)

Prerequisites: AST203 (Astronomy), PHY277 (Computation for Physics and Astronomy), WRT102 (Intermediate Writing



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Search AstroLabSpring24

AstroLabSpring24

Canvases

Slack Connect

Files

Browse Slack

Channels

ast443phy517-spring-2024

general

random

+ Add channels

Direct messages

Simon Birrer you

Victoria

Ben Levine

Jacob Kamler

Marcelo Suquitana

Ryan Brady

Samuel Holden

Zhi Chen

+ Add coworkers

general

general

Homework submission ...

Outside of class, we will use slack for communication - look for an invitation in your e-mail inbox

You're looking at the # general channel

This is the one channel that will always include everyone. It's a great spot for announcements and team-wide conversations. [Edit description](#)

[Add coworkers](#)

Wednesday, January 17th

Simon Birrer 3:00 PM joined #general. Also, Zhi Chen and 6 others joined.

Hi everyone! Let's try using Slack for...

Best way to keep track of slack:
install the App on your computer

AstroLabSpring24

general

Post questions about lectures, computing, etc. in the relevant “channel”. Try to answer your classmates’ questions!

You're looking at the # general channel

This is the one channel that will always include everyone. It's a great spot for announcements and team-wide conversations. [Edit description](#)

Add coworkers

Wednesday, January 17th

Simon Birrer 3:00 PM joined #general. Also, Zhi Chen and 6 others joined.

Hi everyone! Let's try using Slack for...

Send private messages to your teammates, the instructor, the TAs.

general

Team work

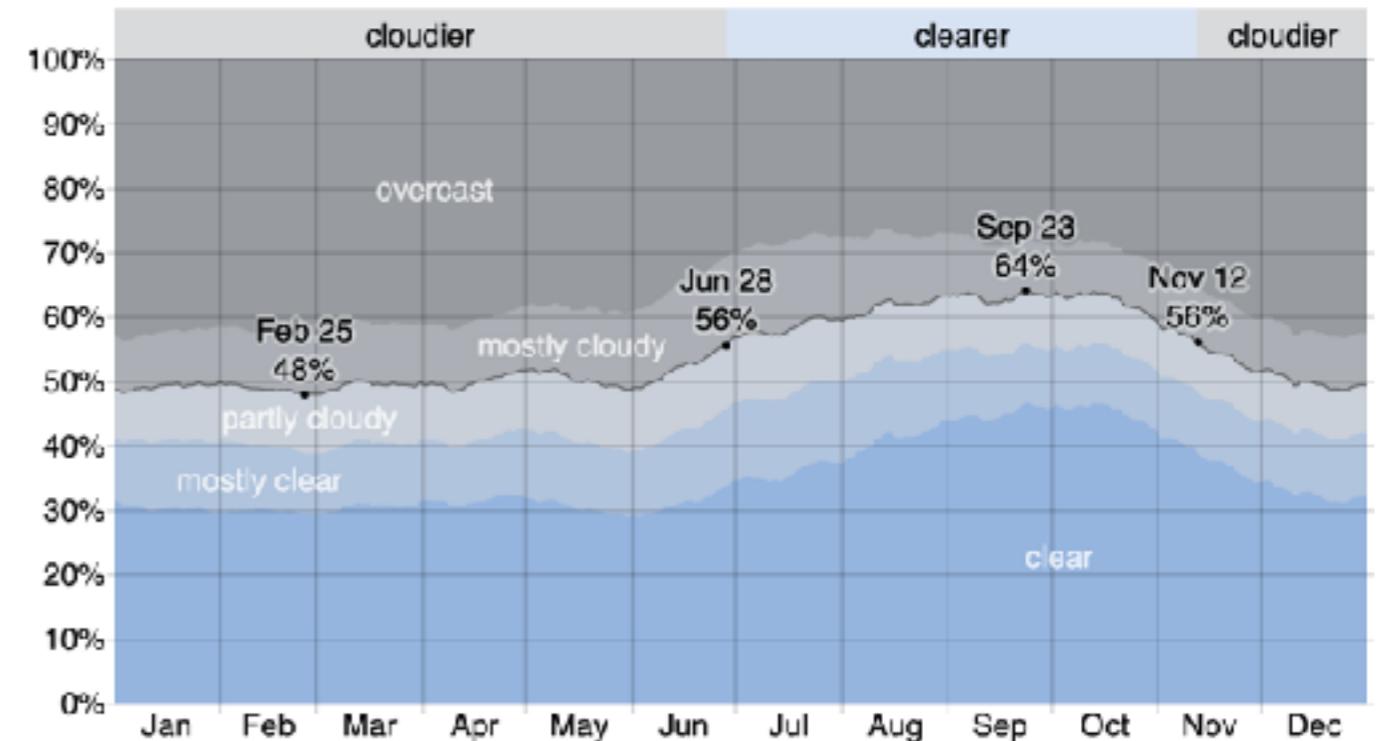
- observational astronomy is done in teams
- for the labs, you will observe in **teams of 2 or 3**
- you are highly encouraged (and expected) to work together on the data analysis
- everybody has to submit individual lab reports (however, proof-reading each other's reports is encouraged)
- I will assign teams based on these criteria:
 - the preferences you submitted
 - weeknight availability
 - diversity: grad / undergrad, Honors / Scholars / WISE, astronomy background, programming background, gender, race, etc.

(Night-time) observing

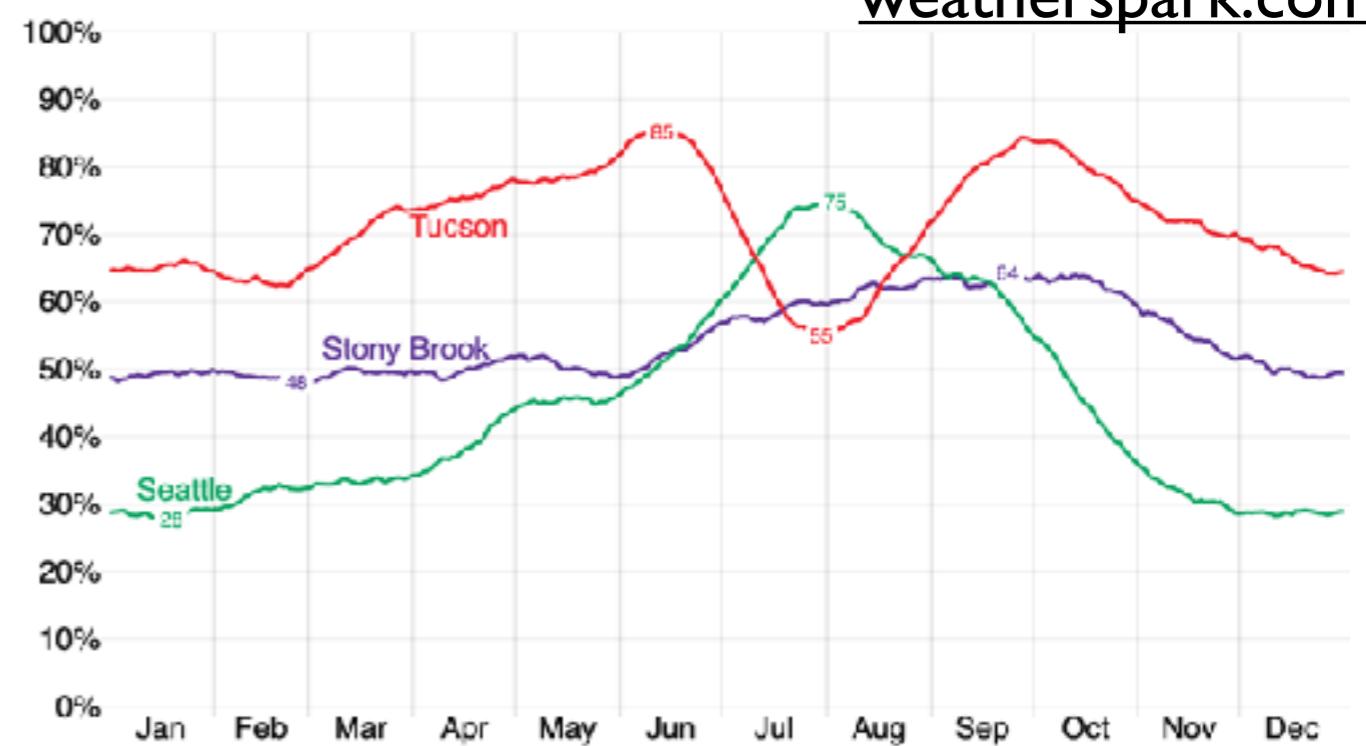
- a TA or instructor must be present (or in the building)
- please plan your observations to be done by ~ 1-2 am
- familiarize yourself with the instructions: **you will be quizzed at the beginning**
- bring:
 - WARM clothes!
 - a red flash-light / rear bike-light
 - a USB key to take your data home
 - all materials needed for the lab: instructions (printed!), finding charts (printed!), your notebook etc.
 - cookies / chocolate

Weather

- biggest problem: clouds are really, really hard to predict!!!
- if there is a chance that you can get your data, you need to take that chance
- often, cannot decide to cancel until the afternoon
- sometimes, we will make the wrong decision...



weatherspark.com



Weather

anjavdl edited this page on Mar 6, 2021 · 4 revisions

[Edit](#)[New Page](#)

Current conditions:

GOES-East loop: https://www.star.nesdis.noaa.gov/goes/sector_band.php?sat=G16§or=ne&band=GEOCOLOR&length=24

Radar + clouds animation from weather.com: <https://weather.com/weather/radar/interactive/l/USNY1412:1:US?layer=radarclouds&animation=true&zoom=7>

Webcam: <http://wx.somassbu.org/DATA/HSC/WX-HSC.php>

Forecasts:

Calsky: <https://www.calsky.com/cs.cgi?obs=72599379422991&Meteo=>

Clear Dark Sky for Mt. Stony Brook: <http://www.cleardarksky.com/c/MtStnyBrkObNYkey.html?1>

Windy: <https://www.windy.com/40.926/-73.141?clouds,40.451,-73.141,7,m:eNnad7g>

4 models: ECMWF, GFS, NEMS, NAM
~~-----~~

Ventusky: <https://www.ventusky.com/?p=40.92;-73.15;6&l=clouds>

4 models: GFS, ICON, GEM, HRRR
~~-----~~

+ Add a custom footer

Long-term forecast models: ECMWF, GFS

Short-term forecast models: NAM, HRRR

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End-of-night report

- when observing, it is imperative that you let the daytime crew (i.e me) know how the observations went ASAP
- fill out the end-of-night report (linked from wiki) at the end of your observations
- if there were problems, describe them in detail

How much time was lost due to clouds? *

- 0%
- <25%
- 25-50%
- 50-75%
- >75%

How much time was lost due to technical issues? *

- 0%
- <25%
- 25-50%
- 50-75%
- >75%

Describe any technical issues you encountered.

Your answer

Other comments

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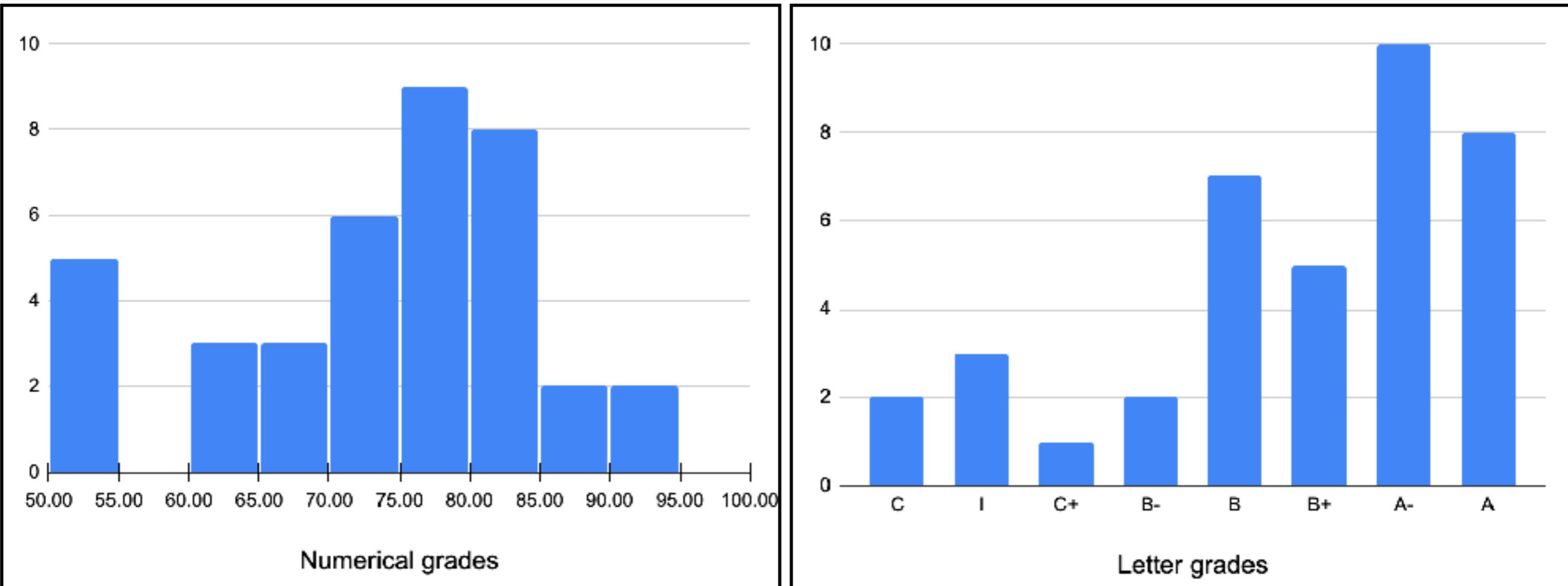
Note

- you are responsible for your own transportation home after observing
- please do not ask the TAs for a ride home! they have to be here way more nights than you, and are also taking classes
- if you live on campus, you can request a walk escort / ride home: <https://www.stonybrook.edu/campus-safety/#view-residential-safety>

Grading

Assignment	Weight
Lab 1 Analysis + Report	20%
Lab 2 Analysis + Report	25%
Lab 3 Analysis + Report	25%
Homeworks + Participation in discussions	10%
Project proposal + evaluation of peer proposal	10%
Final presentation	10%

Grading



(Undergraduate grades only)

Blind Grading

- Lab reports, proposals and homeworks will be graded blindly.
- Put only your SBU ID as author name, and the SBU IDs of your lab-mates as co-authors.

Attendance

- Attendance is mandatory
- Absences can be **excused** e.g. when you are feeling ill and/or in isolation
 - let me know beforehand
 - take a Covid test for symptoms
 - will arrange zoom call-in as fitting
- **Unexcused** absence from lecture, tutorial or data analysis session: 1 grade point (out of 100) penalty on final grade
- You can miss 2 non-consecutive data analysis sessions without penalty (**but need to let me know**)
- **Unexcused** absence from Time Allocation Committee / final presentation: forfeit of participation points
- **Unexcused absence from your scheduled observations:** 50% penalty on lab report grade

Scientific Writing

- Writing is ~50% of the job of a scientist!
- Labs 2 and 3, proposal: in style of scientific papers
- make sure you know how to write a scientific article!
- read scientific papers to see examples
- guidelines on wiki

Significant digits

Code output with way
too many digits:

99.123456789
 ± 0.004556789

Round the uncertainty
to one (or two) digits:

$0.00455679 \rightarrow 0.005$

The location of this
digit tells you the
location of the last
significant digit:

99.123
 ± 0.005

Voila:

99.123 ± 0.005

Lab Reports

- every lab comes with weekly deadlines to show us your progress / hand in your report
- e.g. Lab 1: report due 3 weeks after observations
- late penalty: for every day the data analysis check-in / the report is late, the final grade is multiplied by 0.95
- Example:
 - Initial grade of 80%
 - One day late: $0.80 \times 0.95 = 0.76$
 - Two days late: $0.80 \times (0.95)^2 = 0.72$
 - Three days late: $0.80 \times (0.95)^3 = 0.69$
 - One week late: $0.80 \times (0.95)^7 = 0.56$
 - Two weeks late: $0.80 \times (0.95)^{14} = 0.39$

Delay Days

- Occasionally it's just really hard to meet a deadline...
- Everybody gets 7 “delay days” at the beginning of the course
- You can trade in delay days to avoid late penalties (for lab reports and data analysis check-ins, NOT proposals / presentations)
- For data analysis check-ins, delay days have to be used as a group (everybody “spends” a delay day)
- For lab reports, delay days can be used individually

Keeping track

For each group, we will set up a google sheet to track your lab dates, deadlines and delay dates

	A	B	C	D	E	F	G	H
1	Lab	Observations	Deadlines		Observer	SBU ID	Delay Days	Class absences
2								
3	Lab 0	2018-09-06	2018-09-13				1	3
4			2018-09-20				0	2
5			2018-09-27				0	1
6								
7	Lab 1	2018-10-01	2018-10-18					
8		2018-10-09	2018-10-25					
9		2018-10-11	2018-11-01					
10			2018-11-08					
11								
12	Lab 2	2018-11-01	2018-11-15					
13		2018-11-06	2018-11-22					
14		2018-11-08	2018-11-29					
15			2018-12-06					
16								
17	Lab 3	2018-10-24	2018-11-21					
18		2018-11-12	2018-11-28					
19		2018-11-14	2018-12-05					
20			2018-12-12					

Plagiarism

- Any incidence of plagiarism will automatically result in a final grade of “Q” (Academic Dishonesty).
- Examples of plagiarism specific to this course:
 - Copying parts of somebody else's lab report verbatim
 - Copying parts of somebody else's lab report, slightly modifying each sentence
 - Copying somebody else's observing proposal
 - Using AI and not referencing the original source
 - ...

Plagiarism

- The first “Q” grade means:
 - You lose your scholarship
 - Class penalty ranges from an “F” for the assignment to an “F” in class
 - You have to enroll in a special class (the “Q” class), otherwise the “Q” will become an “F”
- Full policy available at https://www.stonybrook.edu/commcms/academic_integrity/policies_procedures/index.php and https://www.stonybrook.edu/commcms/academic_integrity/students/faq.php

“This class sounds tough...”

- This course was, by far, the best laboratory I have ever taken at Stony Brook. It is one of the best courses I have taken period. In only one semester, I was able to meaningfully participate in the scientific process in a way that was engaging, rigorous, educational, and purposeful. I learned about python, astronomical equipment, the astronomical bodies I studied, how to write research proposals, how to write scientific papers etc. The list goes on and on.
- This course offers immense value to students with a desire to pursue academic research in the field of Astronomy. This course was difficult, time consuming, and the instructor has very high expectations of her students, which are merited. If we want to pursue research, fundamental skills must be developed. It was nice to be challenged, and I feel strongly that this course helped me improve as a student.
- It gave a sneak peek into the life of an astronomer.
- This is an extremely valuable class for astronomy students interested in going into research. It's really impressive that we were able to use legitimate equipment, targets, and techniques that real observers would use. It's rare that an undergraduate class would give this much real-world experience.
- I learned a lot in this course. The student is responsible to figure out how to do most everything in this class especially when analyzing data from lab experiments and this really prepares students to go into graduate school and into research as an astronomer. I improved my skills in coding, LaTeX, and writing scientific papers in this course. The TAs were very helpful during lab experiments.
- I appreciated that each report covered an area of astronomy very well. Putting in the effort, you can learn the relevant softwares/computing techniques used throughout the course associated to each topic. I also gained much deeper understandings of astronomy techniques, such as how an exoplanet light curve is constructed from just a series of images.
- I learned hands on observational astronomy techniques, I improved my writing skills and I also strengthened my coding skills. What makes this course so valuable is that the experiences I had in class will provide me with useful skills in my career.
- This course gave me a nice insight into the observational world of Astronomy. This was the first time i have been able to get hands on experience with observations.

Speaking of workload

- There's a lot of work to be done... 3 labs + reports, proposals + evaluations, final presentations
 - It is unavoidable that **you will be working on more than one assignment at a time**
 - The weekly analysis check-ins are meant to help you by dividing the work into manageable chunks
 - Start scheduling your observations as early as possible to avoid too much work pile-up!
- By spacing out what needs to be done. At one point, we had to hand in a fully finished lab report, a data analysis check in of another lab, and had to observe for the third lab all in the same week. This class is extremely labor intensive and you will end up doing most of the things last minute because of other classwork.
- 
- Avoiding this situation is
your responsibility!

Again...

- this is NOT an “easy” class to avoid the physics lab!
 - you will have to work hard
 - you will have to figure out things on your own
 - this class will challenge you
-
- ... for many of you, it will be the closest thing to actual research that you have encountered so far

Undergrad Writing Requirement

From undergrad bulletin:

E. Upper-Division Writing Requirement:

Students are certified as satisfying the upper-division writing requirement by registering for the 0-credit [AST 459](#) and completing writing projects within their major. All students majoring in Astronomy/ Planetary Sciences must submit two papers (term papers or independent research papers) to the Astronomy coordinator for Department evaluation by the end of the junior year. If this evaluation is satisfactory, the student will have fulfilled the upper- division writing requirement. Papers should be written in the form of a journal article. All papers must consist of an abstract, introduction, main content, and references. References should be cited throughout the text. Any figures should be numbered and have an appropriate caption. If you are using a lab report for the basis of this requirement, you should expand upon the introduction and describe the connection to topical scientific research.

The topic of the WR needs to be original, meaning that Labs 1-2 are not eligible. You're welcome to discuss with me whether your Lab 3 is suitable.

PHY writing requirement will be treated the same as AST.

COVID

- it's still around...
- please be aware that you do not know other people's risk factors
- I may or may not wear a mask when we're not social distancing (e.g. the data analysis help session), but not when upfront lecturing