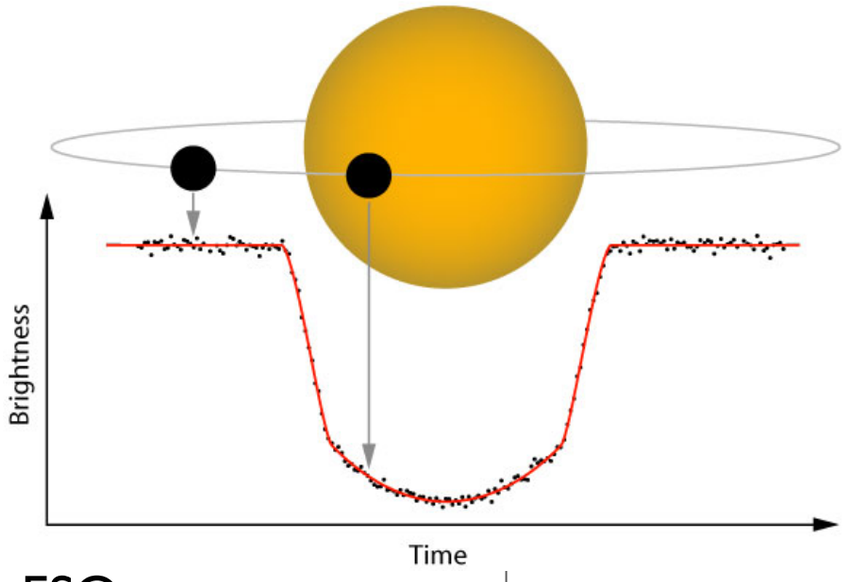
PHY 517 / AST 443:
Observational Techniques in Astronomy

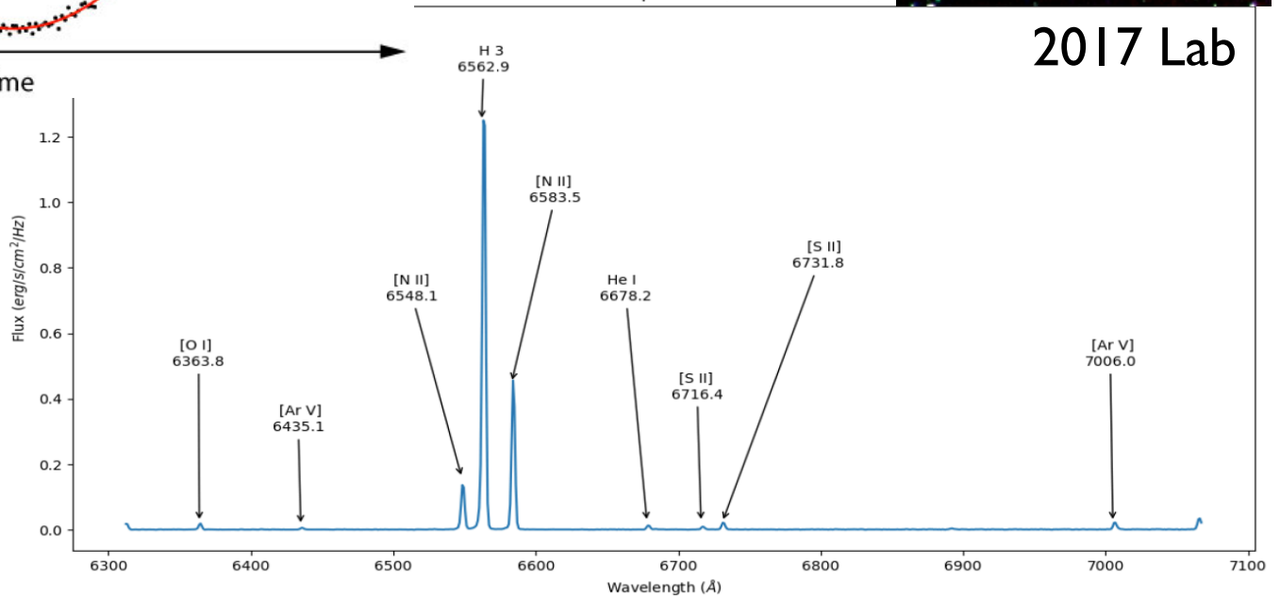
Anja von der Linden

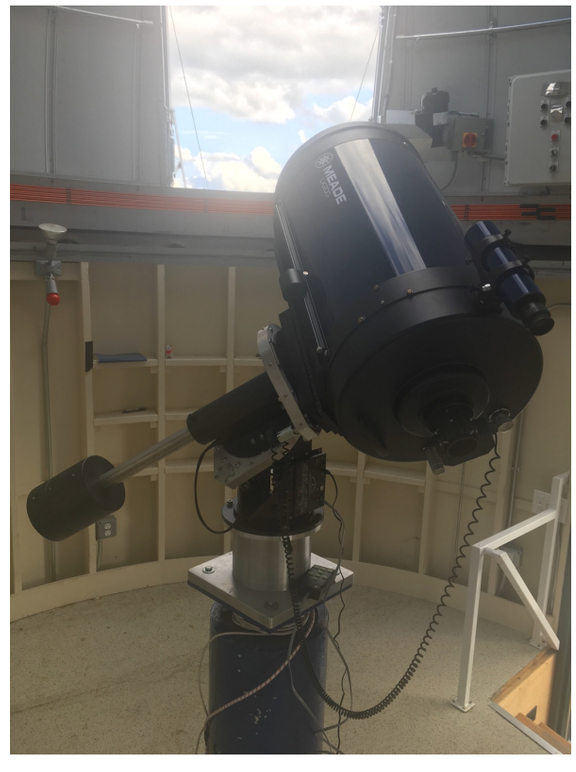


ESO

SBU Astro Club

2017 Lab





AvdL

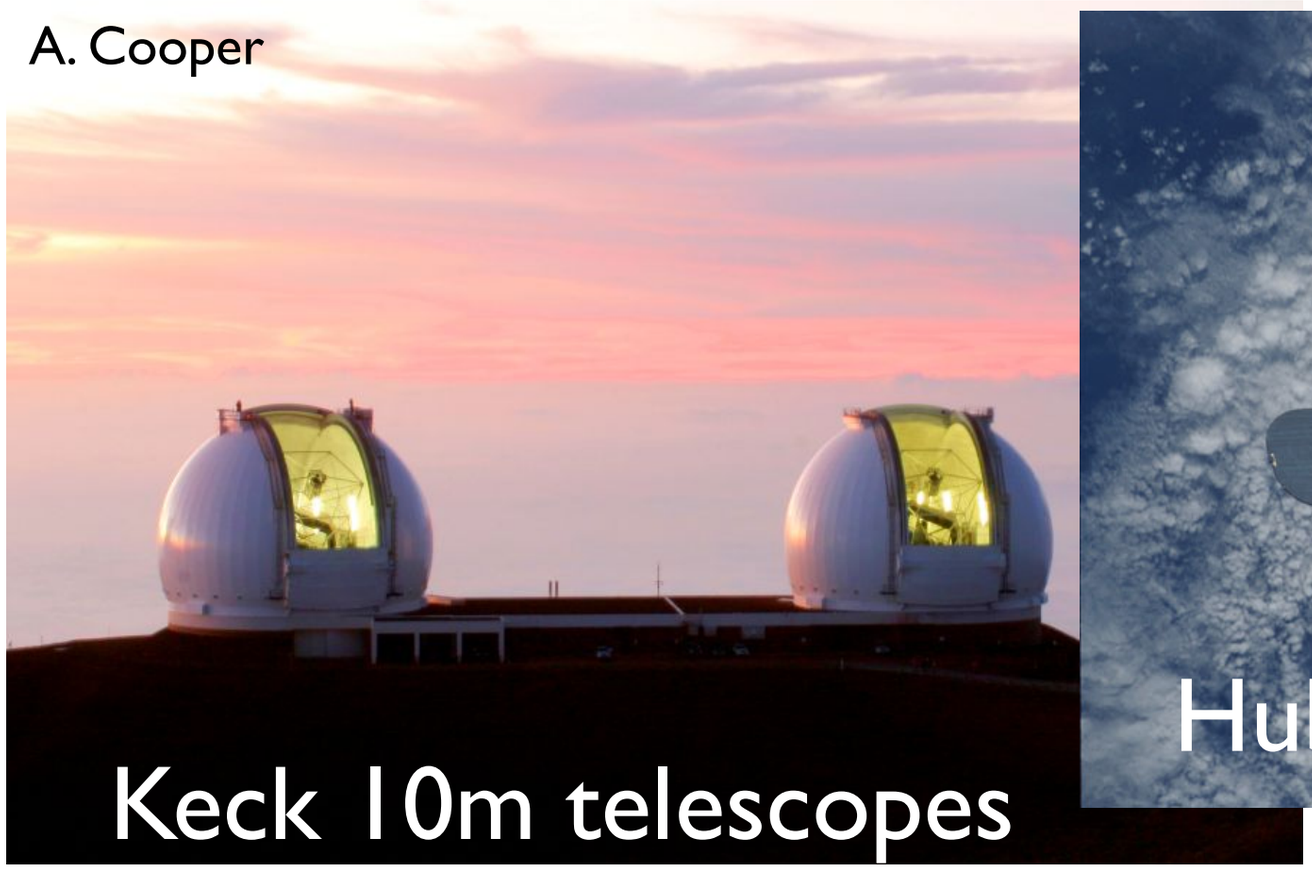
Fall 2019

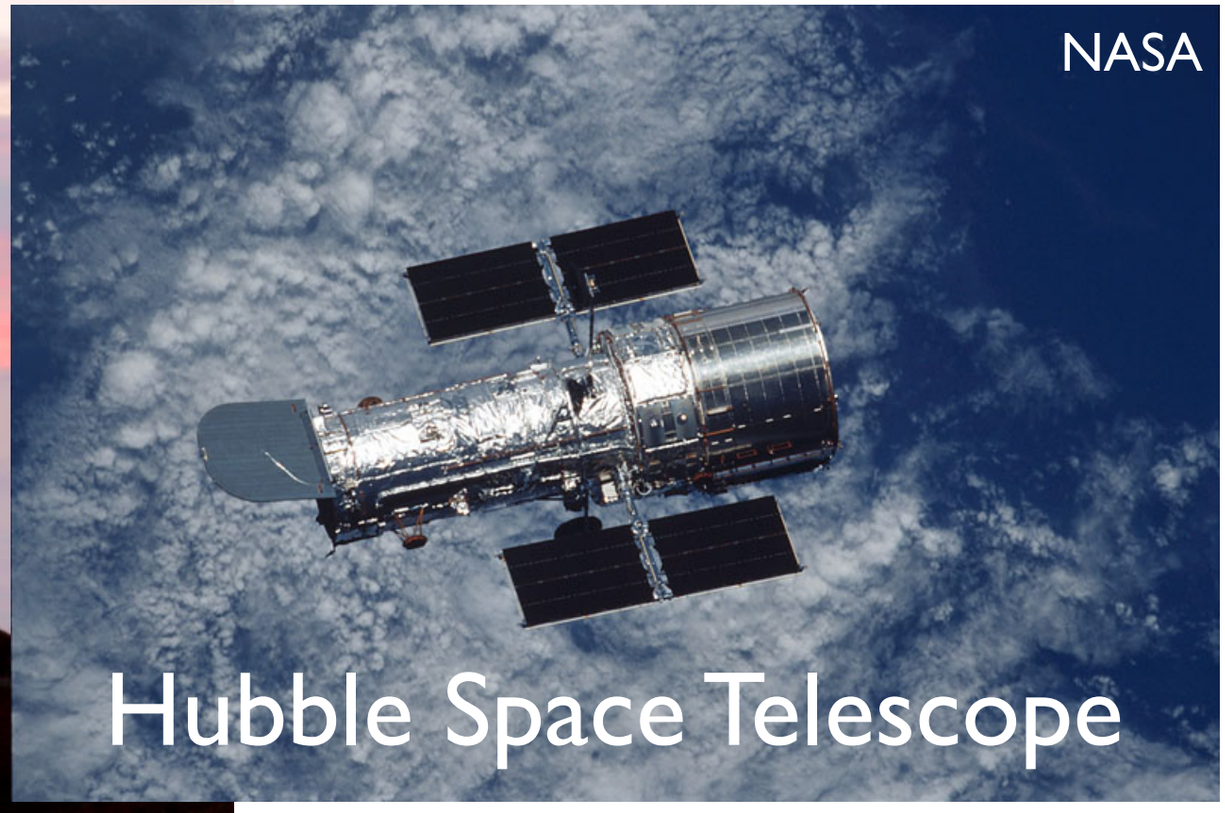
Course Purpose

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

Course Objectives

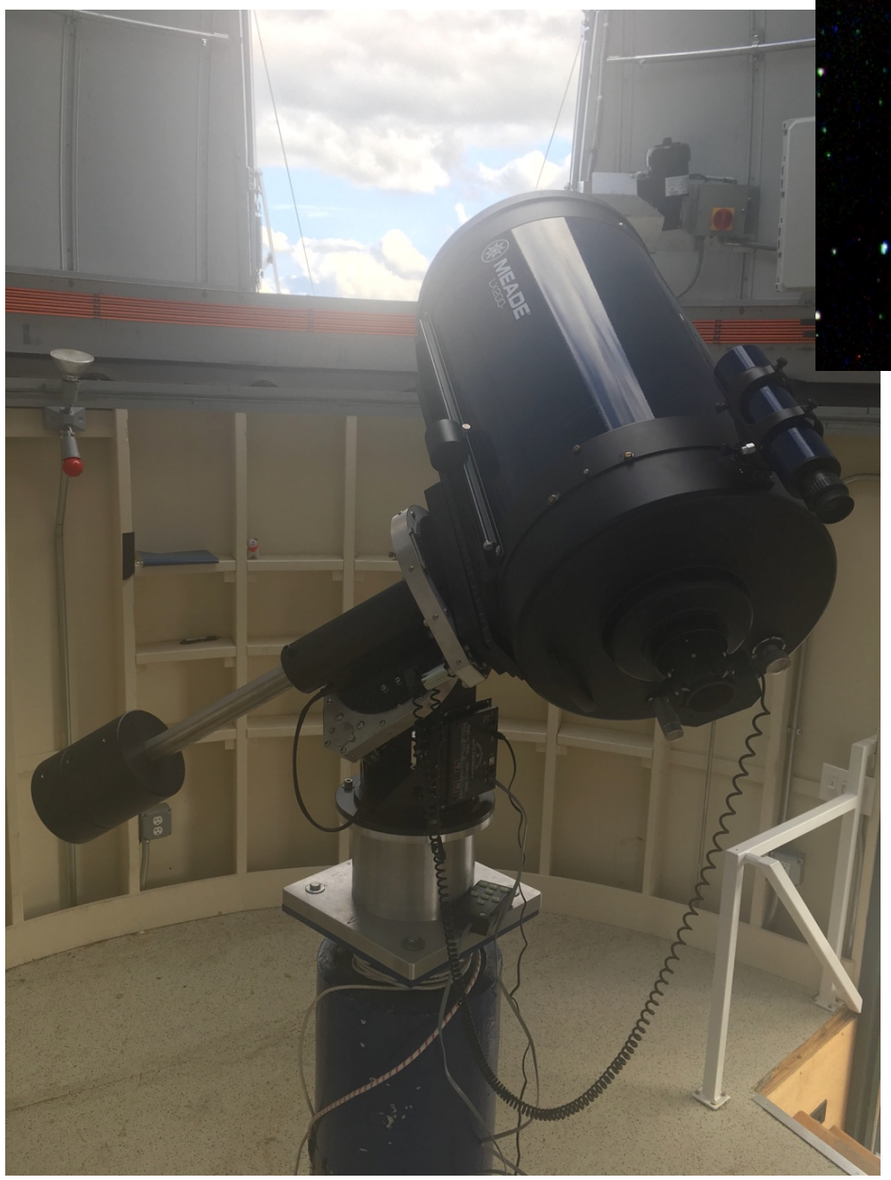
- introduction to observational astronomy
- design, take, analyze and interpret astronomical observations
- report your work in a scientific paper
- same concepts as needed for these:

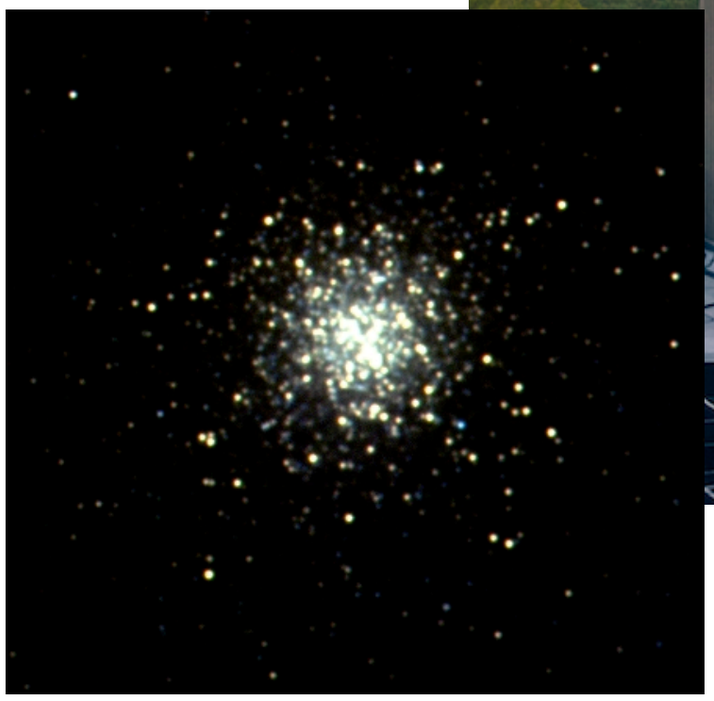




Mt Stony Brook Observatory

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





SBU Astronomy Club

How to be an astronomer

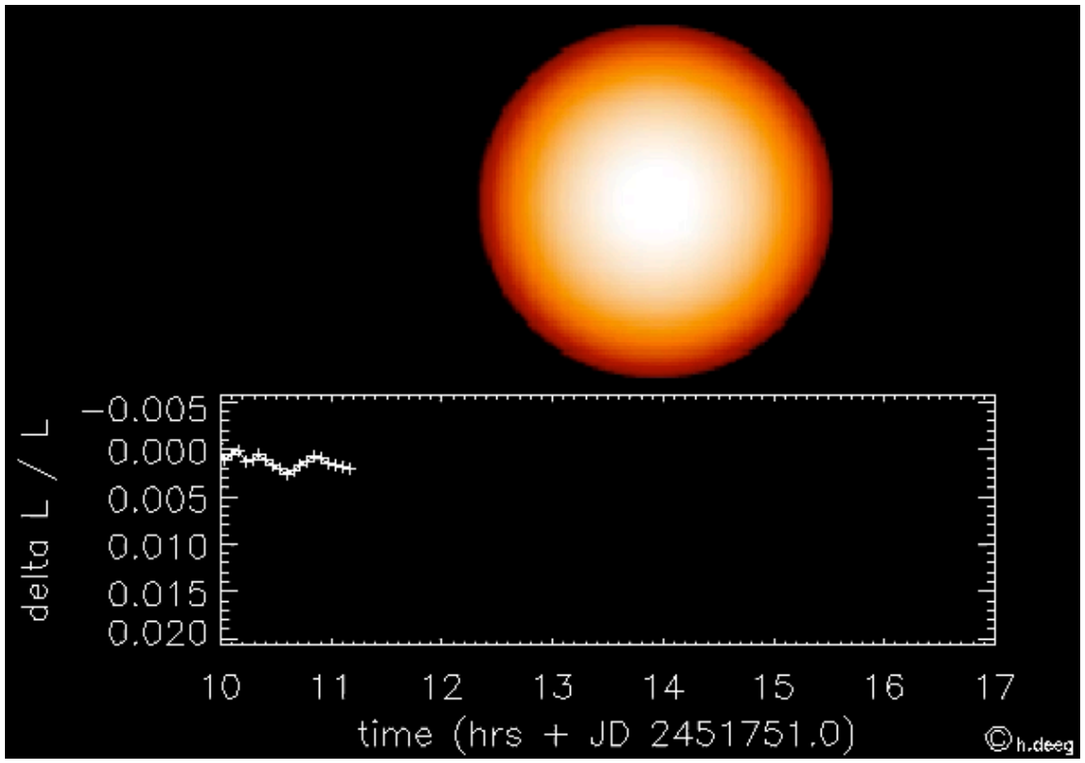
1. come up with an interesting idea / hypothesis
2. search for and analyze archival observations
3. write a telescope proposal
4. plan and execute your observations
5. analyze your data
6. write a journal paper
7. present your work at conferences

Lab 0 - CCD cameras

- measure properties of our CCD cameras
- understand the role of calibration data
- familiarize yourself with the equipment

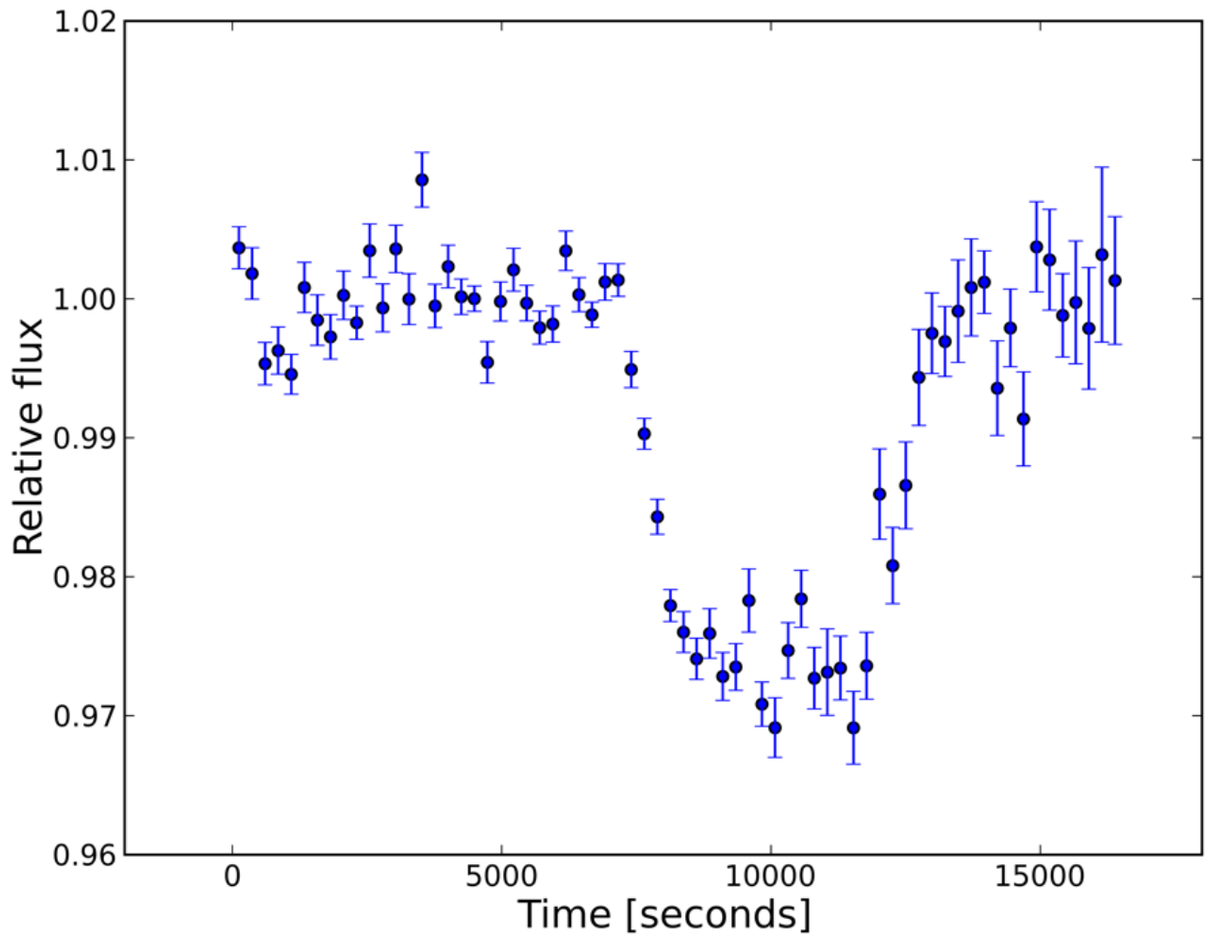
Lab 1 - optical imaging; time-series photometry

- detect an exoplanet transit



Deeg & Garrido 2000

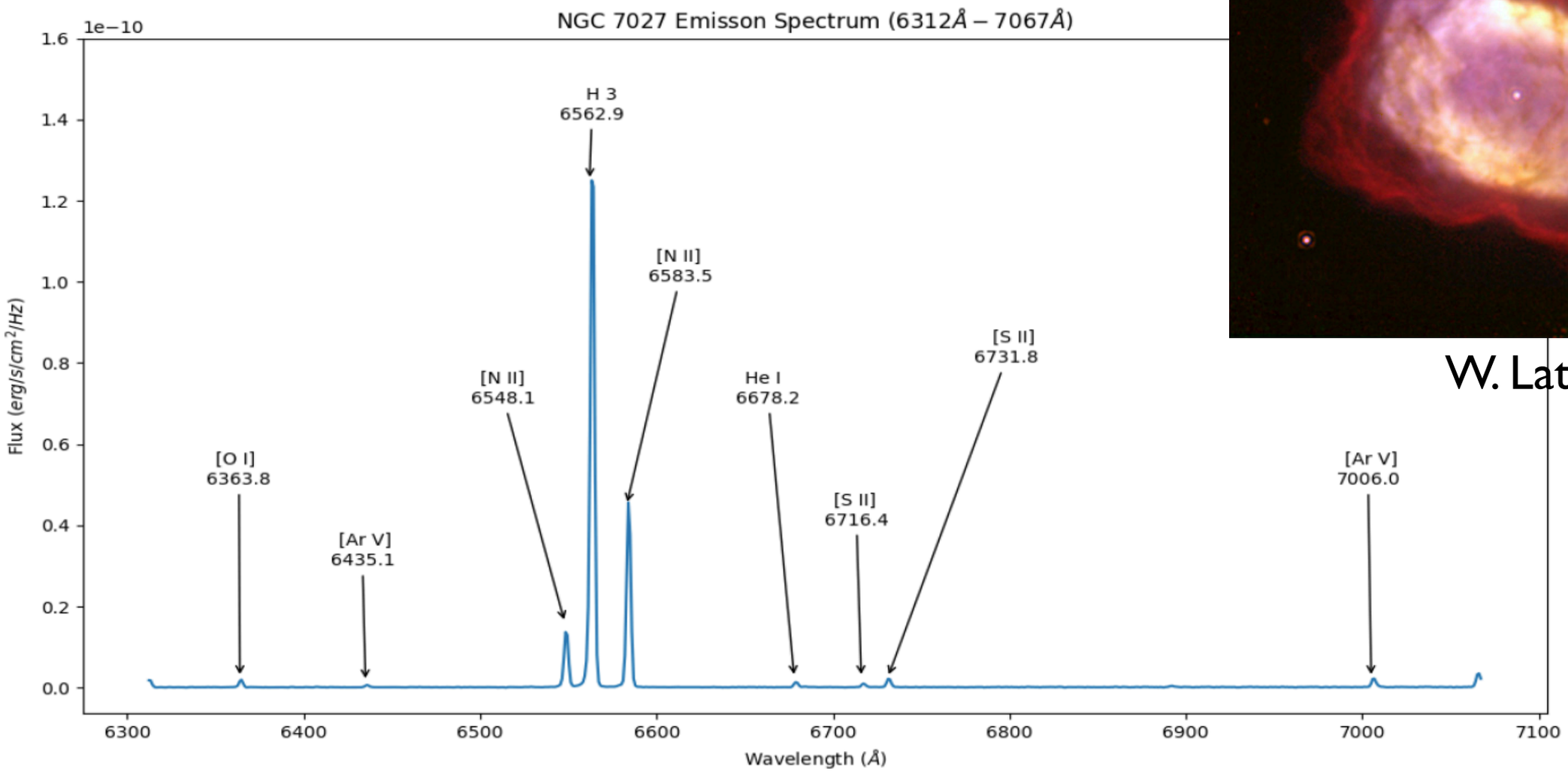
2016 lab

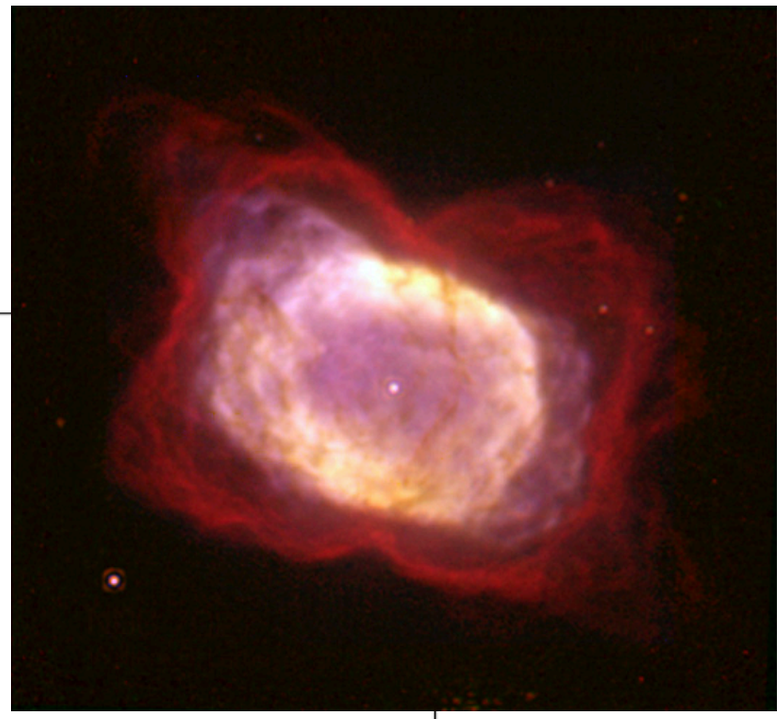


Lab 2 - optical spectroscopy

- measure the gas temperature of a gaseous nebula

2017 lab





W. Latter / NASA

Lab 3 - your proposal

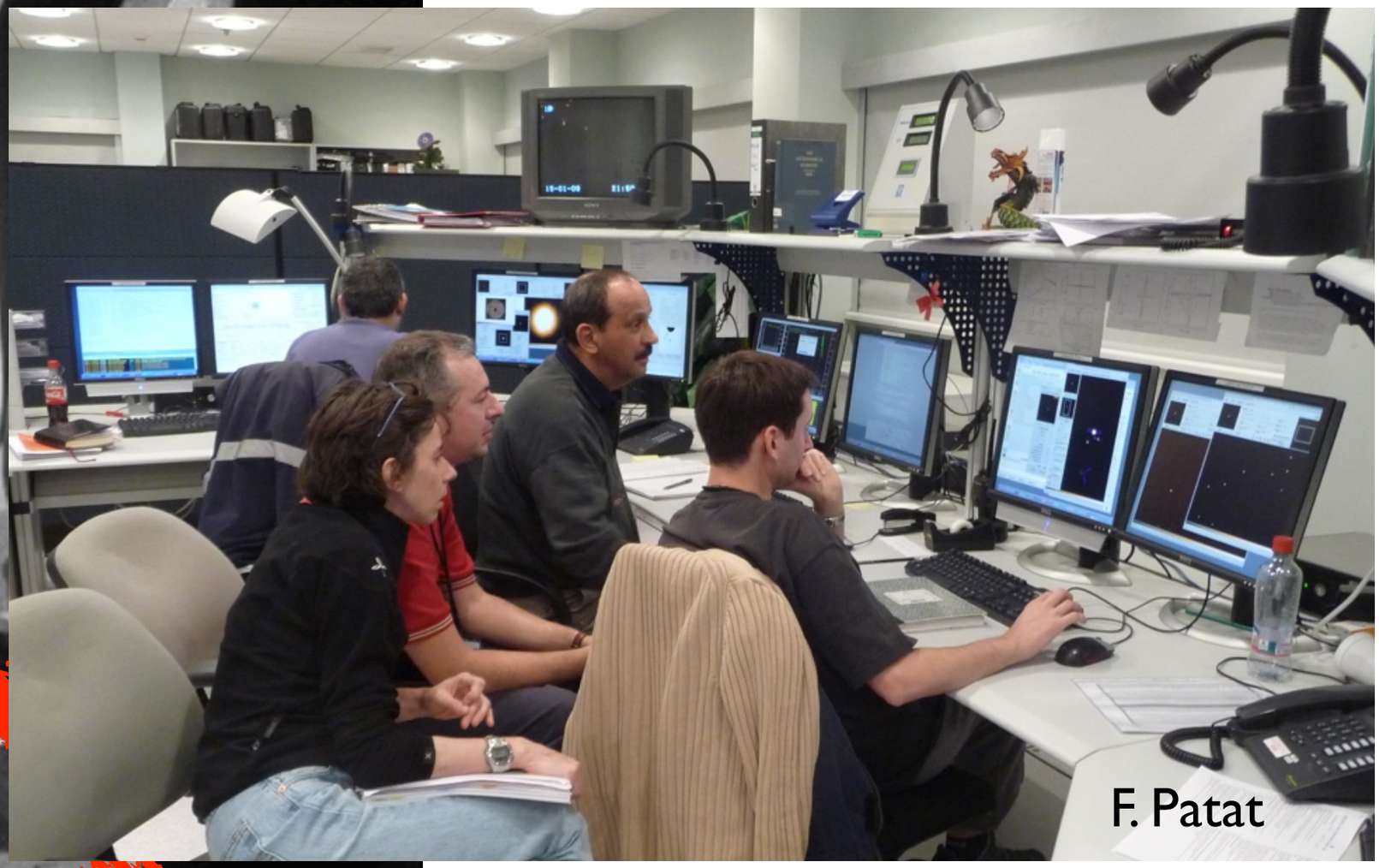
- come up with your own project idea, write a telescope proposal
- we will hold a Time Allocation Committee - just like real astronomers!
- each lab team will conduct their top-ranked project

Data analysis

astronomy ~100 years ago:

Mt. Wilson archive

astronomy today:



F. Patat

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 Large Synoptic Survey Telescope (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:
  - Source Extractor
  - ds9
  - pyraf / iraf
  - 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 (google is your friend!)

Computing Resources

- all necessary software is installed on two machines in the Astro Computing Lab (uhura and vulcan)
- you will receive a piece of paper with your 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 6-9pm

In practice:

- only ~5 lectures
- other sessions: tutorials / data analysis help, as needed
- most important scheduling constraint is that you get to take your observations
- you need good weather for the 3 observational labs
- for each lab: schedule target night + 2 back-up nights
  → 9 nights in total

Course webpage: https://github.com/anjavdl/PHY517_AST443

anjavdl / PHY517_AST443

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General Information

Credits: 3 (PHY 517) or 4 (AST 443)

Instructor: Anja von der Linden (anja.vonderlinden 'at' stony brook.edu, ESS 453)

Office hours: Wednesdays 2-4pm

TAs:

- Shuang Liang (Shuang.Liang 'at' stonybrook.edu)
- Radhakrishnan Srinivasan (Radhakrishnan.Srinivasan 'at' stonybrook.edu)

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 Workshop)

Class times are Mondays and Wednesdays, 6-9pm, in ESS 450, and will be scheduled either as lectures, tutorials, or computing lab time, i.e. the possibility to work on the data analysis in the

Pages 28

General Information

- Schedule
- Grading
- Academic Policies

Labs and Write-Ups

- Guidelines
- How to write a decent lab report
- Observing Equipment
- Observing Calendar
- Lab 0: CCDs
- Lab 1: Exoplanet transit
- Lab 2: Diffuse Nebula Spectroscopy
- Lab 3: Your own proposal
- *Discontinued:* Radio Interferometry
- Weather
- End-of-night report

Computing

- Computing Resources
- Astro Software Overview

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Homework reading until Wednesday

Pages 28

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TAs

Shuang Liang <shuang.liang@stonybrook.edu>

office ESS-443C

Radhakrishnan Srinivasan
<radhakrishnan.rinivasan@stonybrook.edu>

office ESS-443B

Team work

- observational astronomy is done in teams
- for the labs, you will observe in teams of 3 (one group of 4)
- 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 highly encouraged)
- please form teams of 3 people by Wed this week
- please make sure that
  - at least one of you has some programming experience
  - at least one of you has a laptop with Linux
  - you are available on the same week-nights / days

(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, finding charts, your notebook etc.
  - cookies / chocolate

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

- 20% lab 1
- 20% lab 2
- 20% lab 3
- 10% lab 0
- 10% project proposal + evaluation of peer proposals
- 10% final presentation
- 10% homeworks + participation in discussions
- Attendance is mandatory!

Attendance

- Unexcused absence from lecture 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
- Absence from Time Allocation Committee / final presentation: forfeit of participation points
- Not showing up for your scheduled observations: 50% penalty on lab report grade

Lab Reports

- 70% of your grade comes from your lab reports
- make sure you know how to write a scientific article!
- read scientific papers to see examples
- guidelines on wiki

Lab Reports

- every lab comes with weekly deadlines to show us your progress / hand in your report
- Lab 0: report due 3 weeks after observations
- others: report due 4 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

- You all have other constraints (GREs, mid-terms) that will occasionally make meeting a deadline really hard...
- 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
  - ...

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

Final Grades / Curving

- Letter grades will be assigned according to the standard scheme:
  - >93%: A
  - 90% - 92.9%: A-
  - 87% - 89.9%: B+
  - ...
- If curving becomes necessary, there will be separate curves for undergraduate vs. graduate students (since the minimum passing grades are different)

“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 will 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... 4 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!

Scheduling Advice

try to schedule your Lab 1 observations before Sept. 11

Today ‹ › September 2019 Month

MON	TUE	WED	THU	FRI	SAT	SUN
26	27	28	29	30	31	Sep 1
6pm Lecture 1		6pm Lecture 2		New Moon		
2	3	4	5	6	7	8
Labor Day		6pm Lecture 3				
9	10	11	12	13	14	15
6pm Lecture 4		No observing				
		6pm Lecture 5			Full Moon	
16	17	18	19	20	21	22
No observing						
23	24	25	26	27	28	29
					New Moon	
30	Oct 1	2	3	4	5	6

excerpt from Mt. Stony Brook calendar

Again…

- this is NOT an "easy" class!
- 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.

Juniors: you can use one of the lab reports as your undergrad writing requirement, but you have to put some work into it.

Seniors: you cannot use a lab report as your undergrad writing requirement. No exceptions!

My Bio

undergrad: University of Bonn

PhD: Max-Planck-Institute for Astrophysics, Garching

post-docs: Stanford University

Tycho Brahe Fellow, Stanford + Copenhagen

since Dec. 2015: faculty at SBU

How I got interested in astronomy

1990s:
Bayer moved my Dad+family to SE Texas

skies were dark, nights were warm, people were different

How I stayed interested in astronomy

International Astronomical Youth Camp:
spend 3 weeks with ~70 young people from all over the world

Me at big observatories