Astronomy 302: Observational Astronomy

Dennis Zaritsky

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1 Contact Information

Email : dfz@arizona.edu
Office : Rm 328
Office Hours : By appt. either in person or at my personal zoom. Schedule at least 24h in advance to guarantee an appointment. Less advance notice at your own risk.
(https://arizona.zoom.us/j/5478978421)

Teaching Assistant: Donghyeon "Jeff"Khim (email: galaxydiver@arizona.edu)

2 Course Description

This is an undergraduate level class that is intended primarily for ASTR majors and provides an introduction to observational astronomy. Some experience with computers and Python coding is required. We will discuss topics related to data acquisition (optics, telescope, instrumentation, data reduction and calibration - for both optical/IR imaging and spectroscopy) and data analysis (evaluation of uncertainties, statistical treatments). Time permitting the course will also introduce observational facilities and techniques for lower and higher energy photons (radio, X-ray, gamma rays) and other methods (particle observatories, gravitational waves). As part of the class, students will develop their own analysis software using Jupyter notebooks on-line at the DataLab facility hosted by the National Optical and Infrared Research Laboratory (NOIRLab). The final course project will be an astronomical observational project, developed in teams, using either archival or obtained optical imaging. This will be presented in both written and oral form.

3 Learning Outcomes

Upon successful completion of the course, a student will be able:

- to conceptually understand measurement uncertainties
- to formulate a result and its associated confidence level based on those uncertainties
- to utilize Python and exciting software packages to reduce and analyze a wide range of data
- to retrieve and use archival astronomical data from various facilities
- to describe the function of optical/IR telescopes and instruments
- to craft an observing or archival astronomy program
- to calibrate photometric and spectroscopic observations
- to craft an observing or archival astronomy program
- to discuss in-class topics relevant to each week's Python notebook assignment
- to present an independent project at the end of the term in front of the class

These learning outcomes will be met through the attendance of lectures, writing assignments, Python notebook problem sets, an independent, data reduction and analysis research project, and in-class discussions.

4 Grades

Your final course grade will come through assessments of the regular Workbook assignments (20%), two midterms (15% each), a final exam (25%) and the final project plus presentation to the class (25%). The Workbook assignments are to be done independently, but discussions with other students, the TA, or instructor are allowed. If you have a true emergency and cannot attend the final presentation of your project, please contact me immediately with documentation. Workbook grades will be based on demonstrated effort, completion & correctness of the results, and on clarity/accessibility of presentation, including documentation of any code. The final research project will be done in teams but each student will turn in their own project report.

5 Textbooks

None required.

6 Special Materials

Equipment and software requirements: For this class you will need daily access to the following hardware: computer (laptop since you will bring it to class); regular access to reliable internet signal; ability to download and run the following software: web browser, zoom (perhaps). You may want to run the notebooks on your own machine, in which case you'll need Python and Jupyiter, but this is not required (and the TA and I will not necessarily be able to support your private Python installation).

7 Lectures

The lectures will chiefly involve providing the background material for working through provided Python notebooks. Attending the lectures is strongly encouraged, and it will be mandatory to bring your laptop with you to each class. If you know that you will be away at some point in the semester, please let us know in advance so we can accommodate you.

Information contained in the course syllabus, other than the grade and absence policy, may be subject to change with advance notice, as deemed appropriate by the instructor.

8 Workbooks

The Python notebooks include problem throughout, which will be posted in advance of each week on our course website. You are responsible for the entirety of the notebook. You are allowed to work in groups to share ideas, but all code, figures, and write-ups must be your own. Problem sets will be due as specified and submitted via D2L. If there is a true emergency, then please let me know as soon as possible so we can help you.

9 Final Observational Research Project

A significant fraction of the course grade will be your independent observing program. This will be on a scientific question of your choice. The topic will be submitted to me for approval and/or revision. We will discuss opportunities during the class, but you are also welcome to choose an entirely different topic (e.g., galactic planet formation rates). It can either utilize archival data or data obtained at our telescopes. The project grade will consist of:

- 80%: A 2-page science write-up describing the introduction/motivation(i.e., why it is interesting and what you expected to learn from it), a description of the method/equations that you used, comparison with relevant observations or theoretical expectations, your conclusions, and a discussion of how this program could be improved in the future. This write-up should include embedded references. Additional pages (unlimited) to provide any specialized code or other supporting materials.
- 15%: The team will give a final 10-minute in-class presentation covering the same topics (intro, methods, comparison, future).

• 5%: Early in the semester, the team will give a 5 min in-class presentation of the proposed project.

10 Schedule

Week	Dates	Topics
1	Jan 15	Introduction to course: goals, methods, schedule
1	Jan 17	Beginning statistics: probability distributions
2	Jan 20	HOLIDAY
2	Jan 22	In-class work (workbook 1)
2	Jan 24	Uncertainties : what they are, how to estimate, how to propagate
3	Jan 27	In-class work (workbook 2)
3	Jan 29	Coordinate systems/Catalogs
3	Jan 31	Designing an observing program : what to consider
4	Feb 3	In-class work (workbook 3) & Project Planning
4	Feb 5	Introduction to Detectors
4	Feb 7	CCDs continued
5	Feb 10	Project Pre-presentations
5	Feb 12	In class work (workbook 4)
5	Feb 14	No class (observing day)
6	Feb 17	In class work (workbook 4)
6	Feb 19	Optics/telescopes
6	Feb 21	No class (observing day)
7	Feb 24	Optics/telescopes
7	Feb 26	Midterm 1
7	Feb 28	No class (observing day)
8	Mar 3	Facilities Overview
8	Mar 5	Fitting models : techniques
8	Mar 7	In-class work (workbook 5)
8	Mar 10	Instrumental photometry
8	Mar 12	In class work (workbook 6)
8	Mar 14	Atmospheric Effects & Calibration
9	Mar 17	Spring Break
9	Mar 19	Spring Break
9	Mar 21	Spring Break
10	Mar 24	Spectrographs
10	Mar 26	In-class work (workbook 7)
10	Mar 28	Spectroscopy
11	Mar 31	Spectroscopy
11	Apr 2	In-class work (workbook 8)
11	Apr 4	In-class work (workbook 8)
12	Apr 7	Bayesian inference and MCMC
12	Apr 9	Intro to ML
12	Apr 11	Basic Radio Astronomy
13	Apr 14*	Radio Astro/Interferometry
13	Apr 16*	Interferometry & Other topics
13	Apr 18	In-class work (project)
14	Apr 21	In-class work (project)
14	Apr 23	Other topics (IR Observing/Diffraction limited observed)
15	Apr 25	Midterm 2
15	Apr 28	In-class work (project)
15	Apr 30	In-class work (project)
16	May 2	High Energy Observations
16	May 5	High Energy Observations
17	May 7	In-class work (project) - review
18	May 9	Final Exam (10:30-1:30 pm)

11 Academic Honesty

We follow the policies outlined in the Dean of Students code of academic integrity, including cases of plagiarism and cheating (see http://deanofstudents.arizona.edu). We encourage you to work with your peers on the Workbooks. Such collaborations can include a discussion of the qualitative concepts and on the quantitative aspects (i.e., whether you get the same conclusions),but in the end you must do your own work. Academic honesty also extends to printed texts,websites, and video content. If an assignment even only appears to be copied from someone else,or copied from a source without a reference, or copied from a referenced source and only a few words changed, then the assignment will be assumed to be plagiarized. We will give a grade of"F" for the assignment, and further to that the Dean may assign a grade of "F" for the course and/or pursue a more stringent repercussion.

12 Attendance and Classroom Etiquette

Students are expected to attend all lectures and one session at the 61-inch telescope. Please turn off cell phones in class, and refrain from extraneous talking, distracting/discourteous behavior, distracting use of laptops/cellphones, and coming late and/or leaving early.

The UAs policy concerning Class Attendance, Participation, and Administrative Drops is available at:
http://catalog.arizona.edu/policy/class-attendance-participation-and-administrative-drop

The UA policy regarding absences for any sincerely held religious belief, observance or practice will be accommodated where reasonable,
http://policy.arizona.edu/human-resources/religious-accommodation-policy

Absences pre-approved by the UA Dean of Students (or their designee) will be honored,
https://deanofstudents.arizona.edu/absences

The UA Threatening Behavior by Students Policy prohibits threats of physical harm to any member of the University community, including to oneself. See
http://policy.arizona.edu/education-and-student-affairs/threatening-behavior-students

The University is committed to creating and maintaining an environment free of discrimination;
http://policy.arizona.edu/human-resources/nondiscrimination-and-anti-harassment-policy

13 Assistance

We are here to help you, so please take advantage of office hours. Please contact us promptly if you have any questions or concerns regarding this class. The University of Arizona provides a wide variety of resources to help you feel more at home in the UA environment. Examples of student resource/cultural centers include:

- The African-American Student Affairs Center
- The Asian & Pacific American Student Affairs Center
- The Guerrero Student Center
- The Immigrant Student Resource Center
- The LGBTQ+ Student Affairs Center
- The Native American Student Affairs Center
- The Transfer Student Center
- The Veterans Education and Transition Services Center
- The Women & Gender Resource Center

We encourage you to take advantage of the community, support, and learning opportunities afforded by these centers, and to encourage your friends and colleagues to do the same.

Accessibility and Accommodations: At the University of Arizona, we strive to make learning experiences as accessible as possible. If you anticipate or experience barriers based on disability or pregnancy, please contact the Disability Resource Center (520-621-3268, https://drc.arizona.edu) to establish reasonable accommodations and the let me know as well.

Life challenges: If you are experiencing unexpected barriers to your success in your courses, please note the Dean of Students Office is a central support resource for all students and may be helpful. The Dean of Students Office can be reached at 520-621-2057 or DOS-deanofstudents@email.arizona.edu.
Physical and mental-health challenges: If you are facing physical or mental health challenges this semester, please note that Campus Health provides quality medical and mental health care. For medical appointments, call (520-621-9202. For After Hours care, call (520) 570-7898. For the Counseling & Psych Services (CAPS) 24/7 hotline, call (520) 621-3334.