ASTR 541
Cosmology
(Fall 2020)

This class is scheduled to be taught in the LIVE ONLINE modality

Lectures: 11:00 PM - 12:15 PM AZ time TuTh

Location: https://arizona.zoom.us/j/97726530013 , password cosmo

Instructor: Prof. Tim Eifler
Offices: SO312 (currently only remote)
Email: timeifler@arizona.edu
Prof. Eifler's Office hours: Tuesday's after class, same zoom room

Course description: ASTR 541 is a grad level course on structure, origin and evolution of the physical universe from theory and observations of systems outside our own galaxy. It briefly touches on galaxy formation and evolution, active galaxies and quasars but focusses on the relativistic expansion of the universe, the physics of the early universe, the cosmic microwave background, the growth of structures over time, clusters of galaxies and gravitational lensing. The course will explain the main observations that inform our cosmological world model today and the theoretical concepts that motivate said model.

Grading: Your course grade will be based on homeworks (70%), and a term project (paper and presentation in class) (30%). There will be no final exam. The correspondence between final percentages and letter grades will be: **A**:85%–100%; **B**:70%–85%; **C**:50%–70%,**D**:30%–50%; **E**:0%–30%. There is an extra credit option worth 15%, which is a 30min conversation with the instructor about all topics covered in class.

Homework Assignments: Homework will be due on Fridays at 5pm, submission via d2l. There will approximately be 1 problem set every week at the beginning and later every two weeks for a total of $\sim$ 6-8 homework sets. You are encouraged to work together on solving the problem sets and on discussing the science background. Everybody should however write up the solution independently; do not write up solutions you have not understood or contributed to yourself. One homework will be dropped. Extensions to the homework deadline is only possible in extraordinary circumstances, please contact the instructor.

Term Project: The term project is composed of a project paper (6 pages) and a 25+10min presentation that takes place during the last 6 weeks. The general topic is "cosmological data analysis" and the specific topic is at the discretion of the student. The general concept is to repeat a measurement or repeat a specific data analysis in cosmology, to explain the main concepts and results in a paper and to give a concise presentation to the other students. The work needs to have a code component (correlation analysis, regression analysis, MCMC, simulation, etc) and the code needs to made available through github. Please start thinking about your project early and discuss the concept with the instructor multiple times. You have to prepare a 1-page concept paper on your proposed work that

needs to be signed off by the instructor before you can start the project. There will be a homework free phase in which students have time to work on their project.

Texts: We will mostly follow *Galaxy Formation and Evolution*, by Mo, van den Bosch and White. Other excellent reading material is:

- *Extragalactic Astronomy and Cosmology* by Peter Schneider. Excellent textbook for quick overview, complexity ranges between undergrad and grad level. Very good weak lensing chapters.
- *Cosmological Physics*, by Peacock. It wanders off onto topics (e.g. field theory) that we're not going to need. The last few chapters, on cosmological perturbations, are very good.
- *Principles of Physical Cosmology*, by Peebles. Slightly older (early 90's) and overly complete, this is not a good first book on cosmology, but it's really useful once you know what you're looking for to find it).
- *Galaxy Formation*, 2nd Edition, by Malcolm Longair. This book covers many topics to moderate depth and with modern notation. The second edition considerably expands the discussion of recent observations.

Course Objectives and Expected Learning Outcomes: At the end of this course, students will be familiar with complex topics in cosmology such as :

- galaxy formation and evolution (basics)
- galaxy clustering, galaxy clusters, and cosmological structure formation
- weak lensing, cosmic shear, strong lensing
- basics of general relativity, Friedmann Equations
- cosmic microwave background, important CMB missions
- early universe, nucleosynthesis, inflation
- basics of cosmological data analysis, including bayesian inference and Monte Carlo Markov Chain (Metropolis Hastings and Gibbs Sampling)
- basic machine learning applications in cosmological data analysis

Incomplete/Withdrawal: Requests for incomplete (I) or withdrawal (W) must be made in accordance with University policies, which are available at http://catalog.arizona.edu/policy/grades-and-grading-system#incomplete and http://catalog.arizona.edu/policy/grades-and-grading-system#Withdrawal respectively.

Attendance: Class attendance is optional. However, you are responsible for knowing everything that goes on in class, including announcements, course materials, handouts, what has been assigned as homework, as well as any hints, help, due dates, extensions, etc. Especially due dates could be changed, if the majority of the class has found a problem set particularly challenging. All holidays or special events observed by organized religions will

be honored for those students who show affiliation with that particular religion.

Important:

- If you feel sick, or may have been in contact with someone who is infectious, stay home. Except for seeking medical care, avoid contact with others and do not travel.
- Notify your instructors if you will be missing an in person or online course.
- Campus Health is testing for COVID-19. Please call (520) 621-9202 before you visit in person.
- Visit the UArizona COVID-19 page for regular updates.

Course Website: In this class we will make use of D2L. It is your responsibility to check D2L regularly for course announcements/updates and assignments.

Classroom Behavior Policy: To foster a positive learning environment, students and instructors have a shared responsibility. We want a safe, welcoming, and inclusive environment where all of us feel comfortable with each other and where we can challenge ourselves to succeed. To that end, our focus is on the tasks at hand and not on extraneous activities (e.g., texting, chatting, reading a newspaper, making phone calls, web surfing, etc.).

Threatening Behavior Policy: 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.

Code of Academic Integrity: Students are expected to adhere to the UA Code of Academic Integrity as described in the UA General Catalog. See: http://deanofstudents.arizona.edu/academic-integrity/students/academic-integrity.

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

Academic advising: If you have questions about your academic progress this semester, or your chosen degree program, please note that advisors at the Advising Resource Center can guide you toward university resources to help you succeed.

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.

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.

Equipment and software requirements: For this class you will need daily access to the following hardware: laptop or web-enabled device with webcam, headphone, and microphone; regular access to reliable internet signal; ability to download and run software. Jupyter lab or jupyter notebook with some version of python 3 (please go for 3.7 if you are installing from scratch). Latex environment for the term project. github username and access for the term project.

Class Recordings: This class is not recorded. All recordings are subject to government and university regulations. Therefore, students accessing unauthorized recordings or using them in a manner inconsistent with UArizona values and educational policies are subject to suspension or civil action.

Subject to Change Statement: Information contained in the course syllabus may be subject to change as deemed appropriate by the instructor. Updates will be announced.