AST 358 - Galaxies and the Universe

Spring 2020 - Unique No. 46195
TTh 9:30pm — 11am @ WEL 2.110

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Course Description: This course provides an overview of galaxy evolution and extragalactic astrophysics for astronomy and physics majors. Topics include our galaxy and its constituents, including the interstellar medium, properties of galaxies across cosmic time, galaxy formation and evolution, distance measures across large scales and their cosmological implications, and an introduction to cosmology. Intermixed with lectures, our course will incorporate techniques from an inquiry-based approach to learning, including group activities, critical thinking exercises, and open ended analysis. The purpose of this approach is to introduce students to the methodology used by scientists to solve complex astrophysical problems.

Course-Level Learning Outcomes: After taking this course, you should be able to:

- Interpret basic physical characteristics (e.g. temperature, luminosity, mass) of astronomical objects from observations of their radiation (e.g. from real astronomical spectra or photometry).
- Describe various basic processes that are important for the transport of radiation through astrophysical media like the interstellar medium or intergalactic medium.
- Extract information on the physical conditions and major evolutionary stages in galaxies from electromagnetic spectra. Formulate qualitative predictions for how observed spectra of astronomical objects depend on their physical conditions.
- Interpret astronomical observations in order to infer the masses and sizes of extragalactic sources. Similarly, given the mass (distribution) and size of a system, quantitatively predict observations.
- Connect the current features of astronomical objects, like galaxies and the Universe, to their origin and past/future evolutionary history.
- Apply appropriate physical laws / phenomena to an object in order to solve a problem related to an ongoing process in a galaxy.
- Apply physics first principles to scaffold an astronomical problem and outline an approach to solve it (e.g. masses from Virial theorem, free-fall times from Kepler's laws).
- Create a collaborative plan for telescope observations by constructing the detailed technical case, scientific motivation, and collaboratively write a proposal.

Pre-requisites and Core Requirements: The formal pre-requisites for AST358 are upper-division standing or instructor approval, and one of the following: Physics 301 and 303L; Physics 301 and 316; Physics 303K and 303L; or Physics 303K and 316. Astronomy 307 is strongly recommended.

Students who have a firm grasp on the following topics are most likely to succeed in this class: differential, integral, and multivariable calculus, ordinary differential equations, lower division classical mechanics, thermodynamics, electricity and magnetism, and introductory level astronomy. The course relies on knowledge of these concepts and they will not be reviewed explicitly during class time, though example problems will be worked through in class where

appropriate. Students who are struggling with these topics are invited and encouraged to seek out instructor and TA help during office hours.

As examples of astronomy-specific skills and knowledge students might already bring to the classroom, students will be most successful in this class if they feel comfortable doing most of the following:

- Describe the primary ways that light interacts with matter.
- Derive basic physical quantities for astronomical objects from observables (for example luminosity from flux or magnitude).
- Describe how objects behave in gravitational potentials including the interpretation and manipulation of Kepler's Laws and Newton's gravitational law.
- List the basic major evolutionary stages of astronomical objects (stars, planetary systems, galaxies, the universe).
- Rank astronomical objects in the appropriate order based on mass or spatial scales.
- Make use appropriate units at different scales and in different astrophysical contexts. Check the units of a solution to verify that they are correct.
- List the types of instruments that are used to acquire observations, and link them to different types of data on astronomical objects.
- Draw an astronomical problem and describe its components and how the drawing can be helpful to solve the problem.
- Manipulate tables of data in spreadsheet-style environments in order to execute basic computation (arithmetic, sorting) and produce spreadsheet figures.
- Identify and execute existing routines, in an interpreted programming language, that can be used to solve a discrete scientific problem.
- Find information on astrophysical phenomena and objects that is available via websites, and assess its credibility.

Quantitative Reasoning Flag: This course carries the Quantitative Reasoning flag. Quantitative Reasoning courses are designed to equip you with skills that are necessary for understanding the types of quantitative arguments you will regularly encounter in your adult and professional life. You should therefore expect a substantial portion of your grade to come from your use of quantitative skills.

Texts and Materials:

- REQUIRED: One dry erase marker for in-class activities
- REQUIRED: ***Extragalactic Astronomy and Cosmology: 2nd edition*** by Peter Schneider. IMPORTANT: Make sure you purchase the 2nd edition, not the 1st edition (which is more than 10 years out-of-date).
- NO ACTION REQUIRED: Class notes provided by the instructor via *Canvas* class website.
- You will need a non-wifi enabled calculator for exams. It is highly recommended to also bring it to class every day.
- For further reading (optional additional text): *Galaxies in the Universe, an Introduction* by L.S. Sparke and J.S. Gallagher, III

Use of electronics: Students using their electronics for non-class activities are a distraction to those around them. If we find your use of electronics a problem and a distraction to others, we will give one warning and then ask you to leave the classroom, not earning participation credit for that day. Also, if you are distracted by non-academic use of electronics by a fellow student, you can ask them directly to stop or notify the instructor or TA who will follow-up. Due to the

structure of this class space, laptop use is strongly discouraged unless you require it for accommodations or consult with me privately about your needs. Use of electronic notebooks is allowed, but phone use during class (especially for non-classroom related purposes) is strongly discouraged.

Class Structure: This class will combine short lectures with discussions and group activities. It will not be a traditional University lecture course. You will only learn if you participate in class activities, thus attendance and participation is *required*. Do not pack up or leave class early or come late unless you have talked to me in advance, as a consideration to both me and your fellow students.

Class Website and email: The class website is hosted on Canvas and should be checked regularly for updates and messages regarding exam review sessions, course materials, or special events. In addition to the class website, email is recognized as an official mode of university correspondence, so you are responsible for reading your email for university course-related information, and canvas-delivered announcements. Please check your email regularly and frequently and make sure you are set to receive notifications from Canvas as appropriate.

Accommodations for disabilities and/or family responsibilities: If you have any kind of disability, whether apparent or non-apparent, learning, emotional, physical, or cognitive, and you need some accommodations or alternatives to lectures, assignments, or exams, please feel free to contact me to discuss reasonable accommodations for your access needs. Students with disabilities may also request appropriate accommodations from the Division of Diversity and Community Engagement, and from UT's Services for Students with Disabilities. The official wording provided by the university is: The University of Austin provides upon request appropriate academic accommodations for qualified students with disabilities. For more information, contact the Office of the Dean of Students at 471-6259, 471-6441 TTY or Division of Diversity and Community Engagement, Services for Students with Disabilities, 512-471-6259, www.utexas.edu/diversity/ddce/ssd.

I recognize that students with children or family care responsibilities might require special accommodations on occasion. Students are welcome to bring their children to class to cover a gap in childcare, and they should feel free to contact the instructor regarding missed or late work.

Grading Components and Policies: You will receive the grade you earn in this course. There will be no extra credit awarded after the final class period of the semester, and no late work will be accepted, so please be sure to put in your best effort throughout the semester to earn the grade you would like. Your final grade will be composed of the following elements:

Exams = 40%
Homework = 30%
In-class Participation = 20%
Group Final Project = 10%

Here is more information on each of the grade components:

Exams: There will be three closed-notes, closed-book exams covering material discussed in class, as outlined in the class schedule. These exams will be held **during class** and are scheduled for **February 20th**, **March 31st**, and **May 7th**. If you have a legitimate and unavoidable conflict with these exam times (including illness, emergency, University related

conflict or religious holiday), let the instructor know via email at least 14 days before the exam date so that accommodations can be made. There will be no opportunity for last-minute make-up exams, unless there is verified illness or emergency accompanied by a doctor's note or note from the Student Emergency Services office sent directly to the instructor. There will be no final exam for this course.

Homework: There will be ten homework assignments distributed throughout the semester with due dates specified in the calendar below (subject to change at instructor's discretion). Assignments may be consolidated depending on progress through topics. Students are expected to show ALL work for each homework problem; credit will not be given if work is not shown. Partial credit will be given if there is a simple computational error but work is shown. Qualitative questions should be answered in complete sentences. All submitted work should be legible. Group work and discussion is allowed (and encouraged) for homework assignments, but each student must be responsible for their own understanding of the material from each assignment and independently complete the work.

Class Participation: In-class participation is a major component of your grade. You will carry out many group discussions and in-class activities with your table in an assigned seating arrangement (taking special accommodation requests into consideration). Your attendance will be recorded every single class period by the TA. If you are late or leave early (more than 10 minutes) you will only receive half participation credit for the day, unless you have discussed a special reason to excuse your tardiness or early departure with the TA beforehand. You can miss two class periods without it affecting your attendance grade.

Group Final Project: There will be a final group project centered around a proposal for telescope time. The proposal will focus on some aspect of galaxy formation and evolution or extragalactic astrophysics and will be developed over the course of the 1/2nd half of the semester. This project will be collaborative; thus, no individual grades will be given for this assignment but rather a group project grade. A rubric and prompt for this assignment will be shared with the class half way through the semester (right before spring break).

Grades: This class will *not* be graded on a curve. Your grade is calculated to the nearest 1/100th of a percentage point. The average percentage in each of the above grade components will be weighted by the indicated percentage to derive the final course grade, assigned as follows:

93.00—100% = A	80.00 — 82.99% = B-	67.00 — 69.99% = D+
90.00 — 92.99% = A-	77.00 — 79.99% = C+	63.00 — 66.99% = D
87.00 — 89.99% = B+	73.00 — 76.99% = C	60.00 — 62.99% = D-
83.00 — 86.99% = B	70.00 — 72.99% = C-	0 — 59.99% = F

Regarding harassment/assault: Harassment of any sort will not be tolerated in this classroom or related workspaces. Title IX and Title VII makes clear that violence and harassment based on sex, gender, race or national origin are Civil Rights violations subject to investigation and disciplinary action on behalf of the University. The same kinds of accountability and support will be applied to offenses against other categories such as sexual orientation and gender identity. If you or someone you know has been harassed or assaulted, either in the classroom or outside of the classroom space, you can find the appropriate resources through the University Title IX Coordinator (512-232-3992), UT Austin Campus Police (512-471-4441), the Student Ombuds

Services (which can provide *confidential* advice, resources and help; 512-471-3825), and the UT Counseling and Mental Health Center (512-471-3515).

Mental Health Services: College life can be challenging and stressful. Diminished mental health, including significant stress, mood changes, excessive worry, or problems with eating and/or sleeping can interfere with optimal academic performance. Similarly, problems with relationships, family worries, loss, or a personal struggle or crisis can also contribute to decreased academic performance. UT Austin's Counseling and Mental Heath Center (https://cmhc.utexas.edu; 512-471-3515) provides mental health services to support the academic success of students. This includes counseling services, wellness workshops, free and confidential therapy groups, and general information. I encourage you to browse their website and actively seek support if you're experiencing any of these difficulties.

Expectations regarding mutual respect: Astronomy belongs to all people, independent of race, religion, gender, gender identity, gender expression, or sexual orientation. Incidents of discrimination, assault, harassment, threats, intimidation, profiling, or coercion based on membership or perceived membership will not be tolerated. Show each other respect in the classroom no matter perceived knowledge or performance in this class, or any other.

Academic Dishonesty: The minimum penalty for cheating — in any way whatsoever — is receiving a zero on the assignment on which you cheated. The instructor reserves the right to seek a penalty the instructor deems appropriate for the given case of academic dishonesty, including failing the class and being reported to Student Judicial Services. If the academic honesty is sufficiently serious, the instructor will proceed by filing a formal report to the Judicial Services in the Dean of Students Office as is policy. Judicial Services would decide the final penalty after a hearing on the matter. For more information, read in the General Information Catalog about scholastic dishonesty.

Drop date: The last day to drop the class is April 6th. This will require you to go to your college and get a drop form. You then must bring the form to me and get my approval and signature. After this deadline, students must go to the Dean's office, WCH 2.112, to begin the appeal for substantiated non-academic reasons. The last day to drop with the possibility of a refund is February 5th.

Class Material and Schedule: Below is the approximate course schedule and material we will cover on those days. It is subject to some minor changes.

Class Date	**Class Material**	**Relevant Sections of Textbook**	**Assignments Due**
Jan 21	Introduction & Syllabus; Review of Background Material	1.1-1.2; Appendix A/B/C; see review materials on canvas	
Jan 23	Cosmological context: Understanding an evolving, expanding Universe	4-4.1	
Jan 28	Cosmological context: Hubble's law	3.9 (except 3.9.5), 4.3 (see also 8.3)	
Jan 30	Cosmological context: timeline of the Universe	NA	HW 1

Feb 4	Deconstructing galaxies: simple stellar populations	3.5.1-3.5.2	
Feb 6	Deconstructing galaxies: star formation histories	3.5.3-3.5.4	HW 2
Feb 11	Deconstructing galaxies: dust	3.5.5-3.5.7	
Feb 13	Galaxy Luminosity Functions	3.10	HW 3
FEB 18	Galaxy Luminosity Functions continued	3.10	
Feb 20	**Exam #1**	NA	
Feb 25	Emergence of Hubble Sequence	3.1	
Feb 27	Elliptical and Spiral galaxies: basic classifications and characteristics	3.2, 3.3 (see also 10.4, 10.5)	HW 4
Mar 3	Structure of our Milky Way	2.3, 2.4	
Mar 5	Dynamics of Galaxies and associated scaling relations	3.4	HW 5
Mar 10	Dark Matter and Rotation Curves	3.4, 4.4.6	
Mar 12	AGN and supermassive black holes	5.1, 5.3, 5.4	HW 6
Mar 16-20	***SPRING BREAK***	NA	
Mar 24	AGN and supermassive black holes continued	5.1, 5.3, 5.4	
Mar 26	gas in galaxies and associated scaling relations	3.3.3, 3.8.3	HW 7
Mar 31	**Exam #2**	NA	
Apr 2	Finding distant galaxies: LBGs, DSFGs and Quasars	9.1-9.3	
Apr 7	Finding distant galaxies continued	9.1-9.3	
Apr 9	Characterizing the physics of distant galaxies	9.4	HW 8
Apr 14	the star formation rate density	9.6	
Apr 16	IGM and Lyman Alpha Forest	8.5	HW 9
Apr 21	chemical evolution of the universe	3.7	
Apr 23	galaxy clusters	6.6, 6.7	HW 10
Apr 28	Reionization	10.3	
May 5	Review / Survey	NA	Telescope Proposals
May 7	**Exam #3**	NA	