

# GALAXY EVOLUTION AT HIGH REDSHIFT

Monday & Wednesday | PMA 15.216B | 2:00p-3:15p

**Instructor: Prof. Steven Finkelstein** (he/him/his): [stevenf@astro.as.utexas.edu](mailto:stevenf@astro.as.utexas.edu)

**Help Sessions:** (PMA 16.316): W 1-2p, or by appointment

Welcome to AST386! I want to start off by sharing some of my hopes for your experience in this course as we journey together to study galaxy evolution in the early universe. This class is collaborative by nature, and we will work together in a mutually respectful manner such that all of you can master this material. I also look forward to getting to know you and helping with your graduate school journey by engaging you in discussions outside of class about your academic and personal goals. While on our journey I welcome your comments, concerns and criticisms, to help improve this course.

As this course is designed as a foundation for students who are researching extragalactic astronomy, and as an advanced general course for students for whom this knowledge contributes to their general education, aspects of this course may challenge you. However, I am here to support you, and I will strive to foster an inclusive and supportive learning environment where all of you can grow your astrophysical knowledge and skills to best suit your goals. If things aren't going well, whether its personal or academic, please don't suffer in silence. I believe that all of you can succeed with the high expectations set for this course, and I am excited to work with you this semester as you grow your knowledge of the universe.

## What is this course about?

The past few decades have opened the early universe up for discovery, from cosmic microwave background observations allowing a detailed understand of the very early universe, to deep Hubble Space Telescope surveys opening up the epoch of reionization. We are living through a second renaissance, as the JWST is now beginning to push back our high-redshift horizons to  $z=10$  and beyond. This course is very timely, as many of these exciting results will be dropping during this semester!! This course will provide you with a foundational understanding to perform research into galaxy evolution.

It will be a mix of content-based lectures, paper reviews, in-class activities, homework and a main project. The content-based lectures will work with your existing knowledge to build a framework of how galaxies initially form, and then evolve with time. We will discuss key physical processes regulating galaxy evolution, and how galaxies interplay with the process of reionization. The activities and homework will focus on developing practical skills necessary to perform research in this field. ***You will improve skills*** in critical thinking, communication and teamwork.

It is assumed that students in this course have modest experience with Python programming, and an undergraduate-level understanding of physics and astronomy. I recognize all students come in with different levels of background knowledge, so please see me for help if you find gaps in your knowledge.

**Course Learning Objectives: *By fully engaging in this course, by the end of this semester you will...***

### Content Knowledge

- 1) ...be able to describe the history of the universe, including key events related to galaxy formation and evolution.

- 2) ...be able to identify the key physical processes regulating galaxy evolution and reionization, explaining which processes influence different aspects at different times.
- 3) ...be able to solve problems in a collaborative manner, working in groups to practice in-class problems, and outside of class on the class project.

### Practical Application

- 4) ...have gained the ability to evaluate scientific papers from the literature, including the skills of quick interpretation, and constructive criticism.
- 5) ...have learned practical skills enabling them to analyze real observational data related to galaxy evolution research, allowing them to produce relevant scientific results.
- 6) ...have demonstrated an improved ability to communicate information in an accurate and engaging manner through in-class presentations (on literature papers and a research project).

### Synthesizing Your Knowledge

- 7) ...have developed a curiosity for galaxy evolution, growing the ability to construct new questions to understand why the universe is the way it is.
- 8) ...have combined the knowledge learned in lectures and reading to design their own research project, which they will lead from proposal to project fruition.

### The Human Dimension

- 9) ...be able to summarize the history of this field from a personal perspective, learning about the circumstances which led to big advances (important people/groups, technological advances).
- 10) ...be able to describe the contribution of scientists from under-represented groups in this field.

## **My Commitment to Diversity, Equity and Inclusion**

The University of Texas at Austin serves a diverse student body, and it is my intent that all students are able to succeed in this course, regardless of their background. We are diverse in many ways, and this diversity is fundamental to building and maintaining an equitable and inclusive campus community. Diversity can refer to multiple ways that we identify ourselves, including but not limited to race, color, national origin, language, sex, disability, age, sexual orientation, gender identity, religion, creed, belief, ancestry, veteran status, or genetic information. All diverse identities shape the perspectives that students, faculty, and staff bring to our campus.

Astronomy is for everyone, and we must treat every individual with respect. I pledge to you to treat all of you with respect, and I ask that you do the same in return to myself and to your classmates. In the classroom, I will gladly honor your request to address you by a name that is different from what appears on the official roster, and by the gender pronouns you use. I ask you to support one another as you talk about differences in your personal experiences whether relevant to the class or not. I intend to present course content which is respectful of diversity, including highlighting contributions to this field from scientists from underrepresented groups. To accomplish this, your suggestions (in person, email, or anonymously) are encouraged and appreciated.

Canvas will be our main form of communication, so check it regularly and stay up to date on assignments and communications.

## How is my performance in this class assessed?

My goal is this class is for you to meet the learning objectives above. You'll notice "get an A" is not one of them. However, this is a university and I do need to assign grades. I have thus set up the grading structure below, which is aligned with the learning objectives above. You will notice that in many items, you have the opportunity to revise initial attempts to earn full credit. I've modeled this after the peer review process, where papers are not just accepted or rejected; most often, you're asked to do some revisions before full acceptance. Knowing this, if you engage fully in this course, I fully expect each of you to earn an A.

### Your final course grade will be determined as follows:

**20% - In-class participation:** Our time in class will consist of a combination of lectures, in-class activities, and discussions. Your participation in all of these phases will be crucial to your ability to master the material, and meet the course learning objectives. Due to the importance of participation, it will be a large part of your final grade. You are graduate students, thus you are also responsible for your own learning. Thus your participation grade will be based on periodic self-assessments. **Every 5-6 class periods (four times total) you will be asked to fill out a participation self-assessment**, via a Canvas rubric. You are assessing yourself in three categories: 1) Attends class regularly, is on time, limits distractions, 2) Attentive to the lecture, participates in all-class discussions, and frequently asks questions, and 3) Participated in in-class activities, including paper discussions. I ask that you be honest in your self-assessment, and use integrity. I will read through your responses, and be sure I agree before your grade is posted.

**20% - Homeworks:** This course will include a number of take-home homework assignments of varying length (increasing in complexity as you improve your skillset). For each problem on every homework set, you will receive: Pass (full points), needs revisions (pending), or incomplete (0 points). Any problems which need revisions may be resubmitted within one week. My goal is that you earn full points following the revision. As problems will have varying complexity and problem sets will have varying length, the total number of points may be different between homework sets.

**15% - arXiv Paper Presentations:** This semester is a unique time to take this course, as transformative JWST results will be coming out every day. We will learn about these new results together through arXiv paper presentations. There are three grading portions to this grade component:

- I. Presentation (-5%): Each student must present one self-chosen paper on new JWST results from the arXiv. This paper presentation should consist of a computer slide presentation of approximately 15

### Grading scale\*

93.0 - 100	A
90.0 - 92.99	A-
87.0 - 89.99	B+
83.0 - 86.99	B
80.0 - 82.99	B-
77.0 - 79.99	C+
73.0 - 76.99	C
70.0 - 72.99	C-
67.0 - 69.99	D+
63.0 - 66.99	D
60.0 - 62.99	D-
< 59.9	F

\*no rounding

minutes in length, followed by moderating a 10-15 minute discussion. ***You must post your paper to the Canvas discussion board one week prior to your chosen date.*** Your presentation will be graded based on a rubric available to you on Canvas, and you must achieve a rubric marking of “meets expectations” in each category to earn a grade of “Complete”. Presentations graded as “Incomplete” may be re-attempted in a help session (or via appointment) within one week of feedback being received to improve the grade.

2. Questions (-5%): Prior to each class where a paper will be presented (almost every class Week 3 and beyond), each student must have done a quick read (e.g, abstract, figures and captions, and conclusions) of the arXiv paper for that date, and submitted one well-thought out question as a reply to the canvas post prior to the beginning of class. This portion cannot be completed late. Grading: Complete or Incomplete
3. Critical Examination (-5%) Following paper presentations, students must, for three papers, submit a -half-page write-up giving a valid and justified criticism of an aspect of the paper presented. It is ok if this criticism was mentioned in the discussion, but this submission must include a unique discussion of justifiable criticisms in your own words. Grading: Complete, Needs Revisions, or Incomplete. Revisions must be re-submitted within one week of feedback being received.

**25% - Capstone Project:** The largest component of our grade is the class project. This project requires you to perform an *original* research project with a public dataset, complete with a proposal, a written paper, and an in-class presentation. You will use knowledge and skills developed throughout the course to assist in the completion of this project. This project has several components, with the fraction of the project grade in parenthesis:

- Project abstract (5%): This is a one-paragraph description of what you plan to do. This must be approved by me before you begin your project. Due date: February 15, 2023
- Proposal submission (20%): You must write a proposal in the form of an archival proposal, to convince a TAC that your proposed work is relevant. Due date: March 6, 2023.
- TAC Meeting (5%): The class will split into two panels, each reviewing the others proposals, assigning grades, and providing feedback. This will take place on March 8, 2023.
- Journal article (45%): You will write up the results of your project in the form of an ApJ letter (LaTeX required). Due date: April 24th, 2023.
- Class presentation (25%): You will present a 10 minute talk on your project, during the last two weeks of the class (April 17, 19, 24). We will have 5-6 presentations per class (possibly needing to go the full 90 minutes), with five additional minutes for significant discussions and feedback.

**20% - Final Exam:** The final exam in this course will be an in-person oral exam. I will provide a list of -15-20 questions, and draw -3-4 at random to ask each student. This will take place in my office on April 25-27, 2023. The list of questions will be provided by April 17, 2023. Each question will receive a grade of complete or needs revisions (with specific feedback). You have the opportunity to come back to attempt the “needs revision” questions again to earn full points. At that point, the grade is complete or incomplete.

## Are there any required textbooks?

There are no required texts for this class, but there are several relevant textbooks you may find useful, which I'll list here. I have copies of all which can be loaned for short periods.

- High-Redshift Galaxies, Immo Appenzeller.
- Loeb & Furlanetto, The First Galaxies in the Universe.
- Extragalactic Astronomy and Cosmology, Peter Schneider, 2nd edition. You can download a free PDF of this text at: <http://link.springer.com/book/10.1007/978-3-642-54083-7>
- The First Galaxies: Theoretical Predictions and Observational Clues, Editors: Wiklind, Mobasher & Bromm. You can download (for 7 day periods) a PDF at: <https://ebookcentral-proquest-com.ezproxy.lib.utexas.edu/lib/utxa/detail.action?docID=1030570&pq-origsite=primo>

## What is the Course Schedule?

Given the discussion-based nature of this course, I will not attempt to plan exactly every class's topic at this time. However, I do have a list of topics I would like us to cover, in a rough order. I reserve the right to add or subtract from this list, as I gauge your interest in the various topics.

- Introduction to this class and high-redshift astronomy
- Basics: History, Fluxes, Magnitudes, Colors
- From the Big Bang to the First Galaxies: The first 200 Myr
- The First Stars and Galaxies
- Components of Stellar Populations
- Spectral energy distribution fitting
- Ethics in astronomy (open to topics, but includes authorship, reviewing, refereeing, generation of ideas)
- Finding distant galaxies
- Properties of distant galaxies (focus on UV luminosity functions)
- Reionization (includes guest lectures on quasar spectra and Lyman alpha radiative transfer)
- Formation of the first black holes (includes guest lecture)
- Reionization

## What are other policies on exams, assignments, and other course structure?

### Course Website:

Canvas page for this course:

<https://utexas.instructure.com/courses/1351905>

**Course Webpage:** The course webpage on the Canvas system will be updated with course announcements, homework and reading assignments, and deadlines. It is your responsibility to check these on a regular basis. Please come to class prepared, having done the assigned homework. Also please be prepared to participate in in-class discussions and activities, this is for your benefit.

**Collaboration:** Science is by its nature a collaborative field, so I do not expect you to work in a vacuum. Thus while you may work on your homework in groups, any work you turn in must be fully your own.

**Late work:** Arrangements for late submission must be arranged with me prior to the due date.

**Course Conduct:** Please come to class **on time** and prepared, having read the required reading assignments, also please be prepared to participate in in-class discussions and activities. Please silence cell phones before you enter the classroom, and please be respectful of me and those around you by minimizing cell phone use during class. Laptop use is allowed provided you are on task - those browsing the web are distractions to others around you, and will be asked to leave. **Be respectful of others**, especially during in-class peer discussion times, and even if you disagree with them.

**Students with Children:** I recognize the difficulty of being a full time student with children. If you have children, or other family commitments, please come see me to discuss any modifications of the course policies which will maximize your success in this course.

**Email:** Email is recognized as an official mode of university correspondence; therefore you are responsible for reading your email for university and course-related information and announcements. Please check your email regularly and frequently.

**Attendance:** Full attendance is expected. Should you need to miss class, please let me know ahead of time and I can inform you of what you will miss. I acknowledge that personal or research reasons may result in travel, but please limit any absences to at most a few class periods over the semester to ensure it does not affect your learning (or participation grade).

**Academic accommodations (D&A):** This class respects and welcomes students of all backgrounds, identities, and abilities. If there are circumstances that make our learning environment and activities difficult, or if you have medical information that you need to share with me, please let me know. I am committed to creating an effective learning environment for all students, but I can only do so if you discuss your needs with me as early as possible. I promise to maintain the confidentiality of these discussions. Any student with a documented disability who requires academic accommodations should contact Services for Students with Disabilities at 471-6259 (voice) or 512-410-6644 (Video Phone) as soon as possible to request an official letter outlining authorized accommodations. For more information, visit <https://diversity.utexas.edu/disability/how-to-register-with-ssd/>

**Land Acknowledgment:** I would like to acknowledge that we are meeting on the Indigenous lands of Turtle Island, the ancestral name for what now is called North America. Moreover, I would like to acknowledge the Alabama-Coushatta, Caddo, Carrizo/Comecrudo, Coahuiltecan, Comanche, Kickapoo, Lipan Apache, Tonkawa and Ysleta Del Sur Pueblo, and all the American Indian and Indigenous Peoples and communities who have been or have become a part of these lands and territories in Texas.

## University and Course Policies:

**Academic integrity:** The core values of The University of Texas at Austin are learning, discovery, freedom, leadership, individual opportunity, and responsibility. Each member of the university is expected to uphold these values through integrity, honesty, trust, fairness, and respect toward

peers and community. Students who violate University rules on scholastic dishonesty are subject to disciplinary penalties. Ethical conduct is expected at all times. For example, answering Voting Questions to receive credit when you are not in class is unethical. Incidences of academic dishonesty will be reported to Student Judicial Services. For more specific information go to: <http://deanofstudents.utexas.edu/conduct/academicintegrity.php>.

You are responsible for understanding UT's Academic Honesty and the University Honor Code which can be found at the following web address: <https://deanofstudents.utexas.edu/conduct/standardsconduct.php>

- **Sharing of Course Materials is Prohibited:** No materials used in this class, including, but not limited to, lecture hand-outs, videos, assessments (quizzes, exams, papers, projects, homework assignments), in-class materials, review sheets, and additional problem sets, may be shared online or with anyone outside of the class unless you have my explicit, written permission. Unauthorized sharing of materials promotes cheating. It is a violation of the University's Student Honor Code and an act of academic dishonesty. I am well aware of the sites used for sharing materials, and any materials found online that are associated with you, or any suspected unauthorized sharing of materials, will be reported to Student Conduct and Academic Integrity in the Office of the Dean of Students. These reports can result in sanctions, including failure in the course.
- **Class Video Recordings:** Class recordings are reserved only for the use of members of this class (students, TAs, and the instructor) and only for educational purposes and are protected under FERPA. Recordings should not be shared outside the class in any form. Violation of this restriction could lead to Student Misconduct proceedings.

**Plagiarism:** As a research university, the University of Texas at Austin takes plagiarism very seriously. Do not risk getting involved in a plagiarism infraction - the consequences simply aren't worth it. Always cite your sources, and when in doubt consult a professor or librarian. You may also read more about plagiarism at the Student Judicial Services website: <http://deanofstudents.utexas.edu/conduct/academicintegrity.php>

**Personal or Family Emergencies:** If you experience a personal or family emergency (death in the family, protracted sickness, serious mental health issues) that prevents you from attending an exam or forces you to miss multiple days of class, you should contact Student Emergency Services in the Office of the Dean of Students <http://deanofstudents.utexas.edu/emergency/>. They will work with you to communicate with your professors and let them know of your situation.

**Religious Days:** A student who is absent from a class for the observance of a religious holy day will be permitted to make up the missed work, if notice is given at least fourteen days prior to such an absence.

## University Resources:

**Counseling and Mental Health Center (CMHC):** We all benefit from support during times of struggle. Know you are not alone. If you are experiencing signs of stress, anxiety, depression, academic concerns, loneliness, difficulty sleeping, or any other concern impacting your well-being – you are strongly encouraged to connect with CMHC. The Counseling and Mental Health Center is located on campus and provides a wide variety of mental health services to UT students including crisis services, counseling

services with immediate support and well-being resources. Additionally, CARE Counselors are located within each of the academic schools and colleges. These counselors are familiar with the concerns that are unique to their unit's students. For more information on CMHC, visit [cmhc.utexas.edu](http://cmhc.utexas.edu) or call 512-471-3515.

**University Health Services:** Your physical health and well-being are a priority. University Health Services is the on-campus medical facility providing high quality medical care and patient education to UT students. Services offered include general medicine, specialty clinics including the gynecology clinic, sports medicine, nutrition services, allergy, immunization and travel health and physical therapy, an urgent care, a 24/7 nurse advice line, and a lab and radiology services. For additional information, visit [healthyhorns.utexas.edu](http://healthyhorns.utexas.edu) or call 512-471-4955.

**Student Emergency Services (SES):** Student Emergency Services in the Office of the Dean of Students helps students and their families during difficult or emergency situations. Assistance includes outreach, advocacy, intervention, support, and referrals to relevant campus and community resources. If you need to be absent from class due to a family emergency, medical or mental health concern, or academic difficulty due to crisis or an emergency situation, you can work with Student Emergency Services. SES will document your situation and notify your professors. Additional information is available at <https://deanofstudents.utexas.edu/emergency/> or by calling 512-471-5017.

**Important Safety Information:** If you have concerns about the safety or behavior of fellow students, TAs or professors, contact BCCAL (the Behavior Concerns and COVID-19 Advice Line) at <https://safety.utexas.edu/behavior-concerns-advice-line> or by calling 512-232-5050. Confidentiality will be maintained as much as possible, however the university may be required to release some information to appropriate parties.

#### **Classroom Safety and COVID-19:**

For any illness, students should stay home if they are sick or contagious, not only to stop the spread, but also to prioritize their personal well-being. UHS provides [symptomatic COVID-19 testing](#) for students. Schedule your appointment by calling 512-471-4955 or online within the [MyUHS patient portal](#). Learn more about [symptomatic COVID-19 testing here](#). Disposable masks are available for students at the William C. Powers, Jr. Student Activity Center and Texas Union hospitality desks.

The [exposure action chart](#) offers guidance on what to do if you have been exposed to someone who has COVID-19 or if you test positive. If you experience symptoms, stay home and isolate and follow the instructions for symptomatic in the chart. Stay up to date on [COVID-19 vaccinations](#) by getting all available boosters when eligible. Vaccines are available through University Health Services. Additionally, UHS maintains up to date resources on COVID-19, which can be found here:

[COVID-19 Information and Resources](#)

**Title IX Disclosure:** Beginning January 1, 2020, Texas Education Code, Section 51.252 (formerly known as Senate Bill 212) requires all employees of Texas universities, including faculty, report any information to the Title IX Office regarding sexual harassment, sexual assault, dating violence and stalking that is disclosed to them. Texas law requires that all employees who witness or receive any information of this type (including, but not limited to, written forms, applications, one-on-one conversations, class assignments, class discussions, or third-party reports) must report it to the Title IX Coordinator. Before talking with me, or with any faculty or staff member about a Title IX related incident, please remember that I will be required to report this information.

Although graduate teaching and research assistants are not subject to Texas Education Code, Section 51.252, they are mandatory reporters under federal Title IX regulations and are required to report a wide range of behaviors we refer to as sexual misconduct, including the types of misconduct covered under Texas Education Code, Section 51.252. Title IX of the Education Amendments of 1972 is a federal civil rights law that prohibits discrimination on the basis of sex – including pregnancy and parental status – in educational programs and activities. The Title IX Office has developed supportive ways and compiled campus resources to support all impacted by a Title IX matter.

If you would like to speak with a Case Manager for Support and Resources, who can provide support, resources or academic accommodations, in the Title IX Office, please email supportandresources@austin.utexas.edu. A Case Manager can also provide support, resources and accommodations for pregnant, nursing, and parenting students.

For more information about reporting options and resources, visit <http://www.titleix.utexas.edu/>, contact the Title IX Office via email at [titleix@austin.utexas.edu](mailto:titleix@austin.utexas.edu), or call 512-471-0419.