ASTR/PHYS 4070  Extragalactic Astrophysics (Fall 2019)

Professor: Zheng Zheng (zhengzheng@astro.utah.edu, INSCC 326)
Teaching Assistant: Shiyu Nie (Shiyu.Nie@utah.edu, INSCC 305)
Class Times: Mondays and Wednesdays 1:25pm–2:45pm, CSC 13
Office Hours: Tuesdays 11am–12pm or by appointment, INSCC 326
Prerequisites: (ASTR/PHYS 2500) and (MATH 1321 or 2210 or 1260 or 3140);
               MATH 2250 [recommended]
Course Website: Canvas (access through CIS)
Textbook: *Extragalactic Astronomy and Cosmology* by Peter Schneider
           (We will mainly use the 1st edition. If you have the 2nd edition, it also works.)

**Course Description**

This course will introduce undergraduate students to the study of galaxies, one of the most active fields of research in astrophysics. The course is intended for students following the astrophysics emphasis or getting an astronomy minor. The course will focus on understanding both the contents of galaxies and the tools we use to understand their formation and evolution. It will cover galaxies near and far, from the Milky Way to the most distant galaxies visible to us. Topics will include galaxy structure, galaxy dynamics, stellar populations, the measurement of distances, gas and star formation in galaxies, the mass spectrum of galaxies, and evidence of dark matter.

**Course Contents**

- Basics of stellar populations
- Galactic and extragalactic distance determinations
- Structure, kinematics, stellar populations, and chemical composition of the Milky Way
- Structure, kinematics, and stellar populations of spiral and elliptical galaxies
- Scaling relations for galaxies (Tully-Fisher, Faber-Jackson, Fundamental Plane)
- Gas and star formation in galaxies
- Mass spectrum of galaxies
- Basics of galactic dynamics (orbits, potential, and relaxation)
- Supermassive black holes and active galactic nuclei
- Groups and clusters of galaxies
- Brief overview of cosmology
- Observational evidence for dark matter
- Structure formation and properties of dark matter halos
- High-redshift galaxies
- Galaxy formation and evolution
**Course Goals and Objectives**

We will explore the properties of galaxies and study the evolution of galaxies over the history of the universe, which are based on multi-wavelength observations and our theoretical understanding. Recent progress in the field of extragalactic astronomy will be highlighted.

After completing the course, you are expected to be able to

1. develop a basic knowledge of extragalactic astrophysics;
2. build up a basic picture of the structure and dynamics of galaxies;
3. connect observations of stellar populations to galaxy formation and evolution;
4. describe the main processes related to galaxy formation and evolution;
5. present multiple lines of evidence for the existence of dark matter;
6. read and understand professional articles about galaxies.

**Teaching Methods and Grades**

During class time, we will try to do a combination of group problem solving, discussion, and lecture. Your preparation before class and participation in class are crucial, which will join with homework, essay/presentation, and midterm and final exam to determine your final grade.

**Reading Assignments, Attendance, & Participation.** You are expected to complete the assigned reading before each class and bring to class at least one question or one specific topic you want to learn more about. This will count as your attendance and participation grade. Up to two absences can be excused during the semester (without affecting your grade), but to be excused, you need to tell me *in advance* if you will miss class (by written or e-mail notification).

**Homework.** Problem sets will be assigned every two weeks. While you can have discussions with other students (and you are encouraged to do so) when working on the homework problems, you should always do your own derivations and calculations, write up your solutions independently, and turn in your own work. Late work will receive a 10 point reduction (on a 100-point scale) per day it is late. Please contact me *ahead of time* if you need an extension with a justified excuse.

**Midterm & Final Exam.** Midterm and Final Exam will be administered on Oct 2 and Dec 12, respectively.

**Project and Presentation.** Starting after Fall Break, each of you will choose a topic on which to read a few research papers. I will help you choose the topics and papers to read, and each of you will schedule times to meet with me to discuss your project. During the week of Dec 2nd, you will turn in a short paper (essay) summarizing what you learn and give a presentation in class.

**Total Expected Time.** Outside of class, you are expected to spend about 3 hours per week reading and about 3-5 hours on each homework.

**N.B.** Cheating (including copying homework from any sources) will not be tolerated, and zero credit will be given to the exam or assignment for all parties involved.
Final Grade. Your final grade will be determined in the following way.

- Attendance & Participation – 15%
- Homework – 30%
- Midterm Exam – 20%
- Final Exam – 20%
- Essay/Presentation – 15%

Based on a 100-point scale, a letter grade will be assigned as follows:
93-100 (A), 90-92.99 (A-), 87-89.99 (B+), 83-86.99 (B), 80-82.99 (B-), 77-79.99 (C+), 73-76.99 (C),
70-72.99 (C-), 67-69.99 (D+), 60-66.99 (D), Below 60 (E).
Preliminary Calendar & Schedule

We will approximately follow the schedule listed below. The pace of the course will be adjusted for better coverage and understanding of some topics. Assigned reading of the textbook should be done before each class. Additional reading materials will be assigned as needed.

Aug 19 - Introduction & Overview (1.1-1.2)
Aug 21 - Observational Tools (1.3)
Aug 26 - Milky Way Structure (2.1-2.3.3)
Aug 28 - Milky Way Structure & Kinematics (2.3.3-2.4)
Sep 2 - Labor Day
Sep 4 - Microlensing & Dark Matter (2.5)
Sep 9 - Galactic Center (2.6)
Sep 11 - Classification of Galaxies, Elliptical Galaxies (3.1-3.2)
Sep 16 - Spiral Galaxies, Scaling Relations (3.3-3.4)
Sep 18 - Luminosity Function, Supermassive Black Holes (3.5-3.7)
Sep 23 - Lensing by Galaxies (3.8)
Sep 25 - Population Synthesis and Chemical Evolution (3.9-3.10)
Sep 30 - Cosmology Intro (4.1-4.2)
Oct 2 - Midterm Exam
Oct 7, 9 - Fall Break
Oct 14 - Cosmology Intro (4.3)
Oct 16 - Brief History of the Universe (4.4)
Oct 21 - AGN Intro (5.1-5.3)
Oct 23 - AGN Components and Model (5.4-5.6)
Oct 28 - Local Group, Galaxy Groups and Clusters (6.1-6.2.7)
Oct 29 - Morphology-Density Relation, Gas in Galaxy Clusters (6.2.8-6.3.3)
Nov 4 - Cluster Gas and Cluster Mass (6.3.4-6.4)
Nov 6 - Lensing by Galaxy Clusters, Evolutionary Effect (6.5-6.6)
Nov 11 - Structure Formation (7.1-7.4)
Nov 13 - Dark Matter Halos (7.5)
Nov 18 - High-Redshift Galaxies I (9.1)
Nov 20 - High-Redshift Galaxies II (9.2)
Nov 25 - Reionization, Cosmic Star Formation History (9.3-9.5)
Nov 27 - Galaxy Formation & Evolution (9.6-9.7)
Dec 2 - Presentations
Dec 4 - Presentations
Dec 12 - Final Exam (1pm–3pm)
The Americans with Disabilities Act. The University of Utah seeks to provide equal access to its programs, services, and activities for people with disabilities. If you will need accommodations in this class, reasonable prior notice needs to be given to the Center for Disability Services, 162 Olpin Union Building, (801) 581-5020. CDS will work with you and the instructor to make arrangements for accommodations. All written information in this course can be made available in an alternative format with prior notification to the Center for Disability Services.

University Safety Statement. The University of Utah values the safety of all campus community members. To report suspicious activity or to request a courtesy escort, call campus police at 801-585-COPS (801-585-2677). You will receive important emergency alerts and safety messages regarding campus safety via text message. For more information regarding safety and to view available training resources, including helpful videos, visit [safeu.utah.edu](http://safeu.utah.edu).

Addressing Sexual Misconduct. Title IX makes it clear that violence and harassment based on sex and gender (which includes sexual orientation and gender identity/expression) is a civil rights offense subject to the same kinds of accountability and the same kinds of support applied to offenses against other protected categories such as race, national origin, color, religion, age, status as a person with a disability, veterans status or genetic information. If you or someone you know has been harassed or assaulted, you are encouraged to report it to the Title IX Coordinator in the Office of Equal Opportunity and Affirmative Action, 135 Park Building, 801-581-8365, or the Office of the Dean of Students, 270 Union Building, 801-581-7066. For support and confidential consultation, contact the Center for Student Wellness, 426 SSB, 801-581-7776. To report to the police, contact the Department of Public Safety, 801-585-2677(COPS).

Wellness Statement. Personal concerns such as stress, anxiety, relationship difficulties, depression, crosscultural differences, etc., can interfere with a students ability to succeed and thrive at the University of Utah. For helpful resources contact the Center for Student Wellness at [www.wellness.utah.edu](http://www.wellness.utah.edu) or 801-5817776.

Diversity / Inclusivity Statement. It is my intent that students from all diverse backgrounds and perspectives be well served by this course, that students learning needs be addressed both in and out of class, and that the diversity that students bring to this class be viewed as a resource, strength and benefit. It is my intent to present materials and activities that are respectful of diversity: gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture. Your suggestions are encouraged and appreciated. Please let me know ways to improve the effectiveness of the course for you personally or for other students or student groups. In addition, if any of our class meetings conflict with your religious events, please let me know so that we can make arrangements for you.

This syllabus is subject to change and may be modified by the instructor as circumstances dictate. Modifications of due dates and the syllabus will be made on the course’s Canvas website.