NORTHERN ARIZONA UNIVERSITY

College of the Environment,
Forestry, and Natural Sciences

Department of Astronomy & Planetary Science
Astronomy 392– Astrophysics: Galaxy and Cosmology
Spring 2020

Course Information (BBLearn tab: Contacts & Hours)

Meeting Times & Location: TTh 12:45 – 2:00 pm, HLC rm 3104
Credit: 3 credit hours
Instructor: Dr. Lisa Chien
Email: Lisa.Chien@nau.edu
Office: Bldg. 19, Rm. 311
Office hours: **Mon 2—3pm, Tue & Thu 11am—12pm**
Grader: TBD

Course Prerequisites

PHY263 and AST280 (PHY265 and AST391 preferred)

Course Description & Student Learning Outcomes

This course covers the physical properties of galaxies, including the Milky Way)— galaxy structure, formation, dynamics, and distribution in the universe. The last section of the course covers basic fundamentals of theoretical and observational cosmology. If time permits, related topics such as dark matter and active galactic nuclei will also be discussed.

At the end of this course, you should be able to
i) analyze the structure of the Milky Way, disk and elliptical galaxies in scientific forms;
ii) explain dynamics of disk and elliptical galaxies and matter within;
iii) interpret observational results and deduce into relations in extragalactic astronomy;
iv) describe the large-scale distribution of galaxies and the observations that support the Big Bang Cosmology;
v) derive and interpret the fundamental equations of the Big Bang Cosmology;
vi) be prepared to comprehensively read professional articles in journals such as *Annual Reviews of Astronomy and Astrophysics, Astrophysical Journal, Monthly Notices of the Royal Astronomical Society*.

This will be a lecture course that includes in-class exercises, reading assignments, and homework of writing small codes and using programs, including Microsoft Excel, to plot and interpreting the results of those programs.

Textbook & REQUIRED Materials (BBLearn tab: Syllabus & Info)

- ***Galaxies in the Universe***, 2nd Ed., by Sparke and Gallagher III, 2014 Cambridge University
- ***An Introduction to Modern Cosmology***, 3rd Ed. by Liddle, 2015 Wiley
- **Calculator**
- **Laptop** or an accessible computer

- **Programming/graphing software** of your choice (free! See https://in.nau.edu/its/software/)— **Microsoft Excel, MATLAB, Python**, Mathematica, etc.

Assignments & Grading System

Classes Missed	Effect on grade
≤ 3	None
4 — 6	Lowered by 5%
≥ 7	Lowered by 10%

Assessment	Percent
Attendance & Participation	10%
In-class work & Homework	45%
Midterm Exam	15%
Group Project	15%
Final Exam	15%

Grade	Score
A	90 – 100
B	80 – 89
C	70 – 79
D	60 – 69
F	0 – 59

i) **Attendance & Participation:**
- Attendance is taken every class and you are responsible for signing in. Missing class will affect your grade according to the policy above. Documented illness and institutional excuses will be accepted.
- Please bring your calculator and laptop (with programming/graphing software) to class whenever you can.
- **I *ask* that you participate in-class at least once every class (ask a question, answer a question, make some intelligent, sensible sounds, etc)**, and I will keep track of that to make sure that everyone is participating and at the same pace. **Asking at least one question is especially *required* when we have a guest lecturer in the class.**

ii) **Reading assignments:** The first (Ch. 2-3) and the last part (cosmology) of the materials require a lot of physics and math, so in order to keep up with the class, **I strongly encourage you to read the assigned material before coming to class**. Coming to class prepared is also crucial since many of in-class exercises depend on your reading background. If you haven't taken a class that covers the basics (*i.e.* PHY 263, 321 and PHY 390), come work with me in person when you have difficulties.

iii) **In-class work & Homework:**
- **You *cannot* make up the in-class exercise if you miss the class.** In-class exercises often will become your homework assignment. Late assignments will be accepted only with my *previous* permission. No credit will be awarded for homework after it is due.
- I encourage you to work with other students on the assignments, but you must turn in your work ***in your own words,*** including **any programming/plotting codes** you wrote (see Academic Integrity Policy below). Homework that is copied or suspiciously similar will receive a zero for *all students* involved.
- In order to receive full credit for computing problems, you need to turn in both a paper copy of the code and any output. Any plots must have the *axes labeled, with units*. Your code needs to be *commented*. At the very least, the comments should include your name and the date, and what units each variable is carrying.
- This is the biggest part of your grade, so please **expect constant assignments and dues, and heavy workload during the semester**. If you have not taken a class that covers the basics (PHY 265, PHY 321 etc), come work with me in person when you have difficulties. I do not drop any in-class work or homework.

iv) **Exams:** Exams will consist of both qualitative and quantitative questions. Makeup exams are not given except in extreme circumstances, and you *must* provide documentation and arrange with me to take it at a different time before the exam. The necessary equations and constants will be provided on the exam.

v) **Group Project:** *After midterm exam*, you will choose a group of 3-4 people and a project on a topic related to any course materials or current research. an one-page outline with bullets (single line-spacing, figures and references) and make a presentation during the scheduled classes. We will determine the order of presentation a week before. We will determine the order of presentation a week before. Report is due the time of your presentation. There will be intermediate deadlines to make sure that you are making sufficient progress.

University Policies

- Academic Integrity Policy
  Simply two words— no tolerance. *All students* involved will receive zero points on that assignment or exam. If cheating/plagiarism continue, you will receive an F in the class and the Dean's office will be notified.
- Student Institutional Excuses Policy
  Also see the new Faculty Notification Request form if you must miss classes.

Brief Learning Guide

i) Be proactive and ask questions.

Extragalactic/galactic field is a very much ongoing research, and it is an excellent field to apply fundamental physics. The materials are not hard but require patience, which will in turn repay with you lots of fun and accomplishment. Many difficulties may rise simply due to not knowing some *jargons* (definitions, symbols, names etc). But as long as you are patient and willing to learn, you can be an excellent extragalactic astronomer as well!

ii) Think big and accept approximations.

You will find that there are only a few "principles" or "laws" in extragalactic/galactic research; most of the time the best we can do is "formulas" or "relations". This is simply because all the knowledge is empirical, or based on observations, and observations can be limited due to technology or natural conditions. So many times the "relations" can still be evolving, and we approximate many calculations, and so, you have to accept that. In this field, it is not like physics or chemistry or math, where we can find beautiful and precise formula and rules to describe what we see.

iii) Keep progressing and find your resources.

The Universe is so big (like a puzzle) and there is no reason to believe that I know *everything*. I will do my best to guide you to the galaxies and the Universe, and provide you ways to resources, but at times we may have to learn about new observations or theories together. Please feel free to share and participate, and do not worry to make mistakes. We all learn and advance from making mistakes.

Week		T	Th	Text	Topic
1	Jan	14		Ch 1.1-2	Review of stars & Intro to our Milky Way
			16	Ch 1.2-3	Intro to our Milky Way & other galaxies
2		21		Ch 2.1	The solar neighborhood
			23		
3		28		Ch 2.2.1-2	The stars in the Galaxy- distances & vertical structure
			30	Ch 2.2.3-4	The stars in the Galaxy- star clusters, bulge & nucleus
4	Feb	4		Ch 2.3	Galactic rotation
			6		
5		11		Ch 2.4	Milky Way meteorology- the interstellar gas
			13		
6		18		Ch 3.1	Orbits of the stars under gravity
	Feb		20		**GUEST LECTURE: Dr. Scott Barrows (CU Boulder)**
7		25		Ch 3.2	Two-body relaxation
			27	Ch 4.1-2	Satellites of Milky Way & spirals of the Local Group
8	Mar	3		Ch 4.5	The past and future of the Local Group
	Mar		5		**MIDTERM EXAM: Ch1—4**
9		10		Ch 5.1	Star light of spiral galaxies
			12	Ch 5.2-3	Gas and masses of disk galaxies
10					**SPRING BREAK**
11		24		Ch 5.4-6	Disk galaxies: sequence, spiral arms, centers
			26	Ch 6.1	Photometry of elliptical galaxies
12		31		Ch 6.2	Motions of stars in elliptical galaxies
	Apr		2	Ch6.3-4	Elliptical galaxies: stars, gas, dark matter, black holes
13	Apr	7			**GUEST LECTURE: Dr. Deidre Hunter (Lowell Observatory)**
			9	Ch 1-2	A brief history of the Universe and observational cosmology
14		14		Ch 3	Newtonian Gravity
			16		
15		21		Ch 4	The geometry of the Universe
			23	Ch 5	Simple cosmological models
16	Apr	28			**GROUP PROJECT PRESENTATION I**
			30		**GROUP PROJECT PRESENTATION II**
17	May	5			**FINAL EXAM: 12:30—2:30pm**

Academic Deadlines

- ADD/DROP deadline: Jan 23
- WITHDRAWAL deadline (without petition and fee): Mar 23