Course Syllabus

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ASTRON 1121: Galaxies and Cosmology

Term: Spring 2024

Credits: 3

Prerequisites: ASTRON 0113 or 0413; MATH 0240; and MATH 1270 or 0290 or 0250

Suggested Corequisites: PHYS 0477 or 0479

Meeting Time: Tuesdays and Thursdays, 11:00 AM - 12:15 PM, 105 Allen Hall

Instructor: Prof. Evan Schneider

Contact information

Email: eschneider@pitt.edu (email or Canvas is the best way to get in touch with me!)

Office: 304 Allen Hall

Office hours: Monday 11:00 AM - 12:00 PM; Tuesday 3:00 PM - 4:00 PM; or by appointment

Course Description:

This course is an introduction to the study of galaxies and cosmology at an advanced undergraduate level. These fields have advanced greatly in recent years; we will use state-of-the-art datasets to explore the properties of galaxies and the nature of the expanding Universe. We will begin by establishing a cosmological framework for the study of galaxies, then explore the properties of our own galaxy, the Milky Way, move on to the study the formation and evolution of galaxies in general, and conclude by exploring current constraints on models of the Universe now and in the future.

Course Objectives:

This course has two primary objectives:

→ to provide a basic knowledge of galaxies and cosmology, providing sufficient grounding to engage

in undergraduate research in these fields; and

→ to develop skills in exploring astronomical data and solving problems using the Python programming language.

At the end of the course, you should be able to explain, among other things:

• How the Milky Way Galaxy we live in is similar to (or different from) other galaxies.

• Where galaxies come from and how they may transform amongst types

• Why we believe many galaxies have black holes at their center

• What the main constituents of the Universe are

• How the Universe began and what its ultimate fate will be

• How the Universe has grown and changed over time

• How to perform basic calculations, file input/output, and plotting in the Python programming language

Textbook

Extragalactic Astronomy and Cosmology: An Introduction (https://link.springer.com/book/10.1007/978-3-642-54083-7), by Peter Schneider (second edition). **The e-book is available for free via SpringerLink to anyone with a Pitt login**. You are also welcome to purchase a hardcover/paperback version, if you prefer (~$80/$70) (though frankly, the book's many images are reproduced in higher quality on a laptop display than in print).

We will also use the book **Python for Astronomers** (https://prappleizer.github.io) as a reference for programming.

Goals

My main goal is to work with you to make this course engaging, interesting, and fun. Do not hesitate to contact me with any questions or concerns, either by email, Canvas, or dropping by office hours. I need your feedback in order to improve your learning experience! Please let me know if you have issues with the course material, or you would like me to cover some topic that you are particularly interested in. I may not be able to accommodate all requests, but I will certainly try.

Logistics

I will hold regular office hours on **Mondays from 11:00 AM to 12:00 PM, and Tuesdays from 3:00**

I will hold regular office hours on **Mondays from 11:00 AM to 12:00 PM, and Tuesdays from 3:00 PM to 4:00 PM** (these times may occasionally change during the semester, but will always be up to date on Canvas and in this syllabus and any changes will be announced in class). If you cannot make these times, please contact me and we can arrange to meet at another time. I highly encourage you to use me as a resource - the problem sets in this course can be challenging and I want to help you work through them! If you need further help or would prefer to seek help from a tutor, the Department of Physics and Astronomy maintains a Physics Resource Room in 312 Thaw Hall that is staffed by tutors between 9 AM and 5 PM on weekdays throughout the semester. Please take advantage of this service.

Grading Policy

There will be 5-10 problem sets due throughout the course of the semester as well as a midterm exam that will be given during class before spring break and a cumulative final exam that will take place during finals week. There will also be group assignments in the form of python notebooks throughout the semester.

Grade Components:

50% Homeworks
20% Midterm Exam
20% Final Exam
10% Group work

Arrangements for make-up exams must be made well in advance of the exam. Acceptable excuses for missing an exam include being out of town for a verified University-related activity or illness. If you miss an exam for any reason, be prepared to provide a signed letter from your doctor, from the university health service, or from your coach or person responsible for the University-related activity.

In all assignments, the focus will be on showing the correct reasoning. **NO CREDIT** will be given for a correct answer without the reasoning being clearly explained. A great deal of the credit for a problem may be given if the reasoning is correct, but the numerical answer is incorrect for one reason or another. To get full credit for a problem, you *must* give a complete explanation of your reasoning. Occasionally, you may find an answer that is obviously incorrect. For example, say you derived the distance to the Sun to be three miles. In such a situation, you can still get partial credit for the problem simply by recognizing that the answer obviously does not make sense and explaining why the answer is manifestly incorrect. **NO CREDIT** will be given for an answer that has incorrect units unless you comment on the fact that your answer is wrong and take a guess where you may have gone wrong. For example, if you expect an answer that should have units of length (inches, meters,

miles, etc.) but give an answer of 25 seconds you will get no credit unless you comment on this. Finally, your work must be legible. **NO CREDIT** will be given for work that I find illegible. **NO CREDIT** will be given if I find it difficult to follow the sequence of steps. Your work must flow sequentially from left to right across the page and from the top to the bottom of the page. It is your responsibility, and yours alone, to make sure that your work is legible and orderly. You may discuss problems with others on your homework sets, but the solutions you hand in must be your original work. Homework should be turned in by the beginning of class on the day that assignments are due. Late homework will be accepted with the grade reduced by 10% per 24 hours, unless I have approved an extension. I will post all solutions to problem sets approximately a week after the due date. Once I have posted the solutions on Canvas, no late credit may be obtained for that assignment.

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Course Structure

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In recent years, Physics and Astronomy education research has found in a variety of contexts that the most lasting learning comes not from lectures, but from active engagement with material. This course will employ techniques that have proven effective in this regard, in particular group problem-solving. A significant fraction of class time will be devoted to working together in groups of 3-4 students to solve problems or explore data sets.

Students are expected to have read the relevant sections of the textbook or online readings (listed on Canvas) before class. Lectures and in-class activities are a supplement to the textbook, not a replacement. The goal is not for you to understand everything after reading, but you should come to class ready to ask questions about the parts that are unclear!

Attendance

I will not explicitly take attendance, but given the active learning structure of this class, regular attendance is *strongly* recommended. If you are unable to attend classes for a period of a week or more, please email me directly so that we can discuss your situation.

Schedule

Below is a rough outline of what will be covered in ASTRON 1121. This plan may be modified according to student interests, to accommodate questions that may arise during the course, and to adapt to the pace at which we proceed. Chapters refer to the approximate sections in the textbook that correspond to the week's topics.

Week 1 (Jan 9/11): Introduction to the course, basics of galaxies and cosmology (Ch 1)

Week 2 (Jan 16/18): The Milky Way, Magnitudes and Distances, Color (Ch 2); Diagnostic Due

Week 3 (Jan 23/25): MW Structure (Ch 2), Introduction to Python; Homework 1 due

Week 4 (Jan 30/ Feb 1): MW Structure continued (Ch 2), Plotting in Python; Homework 2 due

Week 5 (Feb 6/8): MW Kinematics and the Galactic Center (Ch2); Interpolation and Integrals in Python

Week 6 (Feb 13/15): Other Galaxies (Ch 3); Homework 3 due

Week 7 (Feb 20/22): Galaxy Populations and Scaling relations (Ch 3); Homework 4 due

Week 8 (Feb 27/29): Exploring SDSS catalogues; **Midterm** Feb 29

Week 9 (Mar 5/7): Groups and Clusters of Galaxies (Ch 6), AGN (Ch 5)

Spring break

Week 10 (Mar 19/21): Basic Cosmology: the Friedmann equations (Ch 4); Homework 5 due

Week 11 (Mar 26/28): Basic Cosmology: Distances, Thermal history, the Big Bang (Ch 4); Homework 6 due

Week 12 (Apr 2/4): Large scale structure of the Universe (Chapter 7)

Week 13 (Apr 9/11): Measuring Cosmological Parameters (Chapter 8); Homework 7 due

Week 14 (Apr 16/18): Galaxy Evolution (Chapter 10)

Final Exam Apr 25, 10:00 - 11:50 am

The Department of Physics & Astronomy

As students at the University of Pittsburgh, you have access to a Physics and Astronomy Department that is highly recognized and is performing world-class research. We in the Department of Physics and Astronomy want you to feel welcome. If you are interested in further study of or research in physics or astronomy please talk to me or any other faculty member.

The Department of Physics & Astronomy provides free assistance for all students. The Physics Exploration Center allows students to operate some simple experiments and demonstrations. Within the Exploration Center is the Physics Resource Room, staffed with TAs who can answer homework related questions, explain basic concepts and help you with the math. This is a free service and you

are encouraged to use it. Both the Exploration Center and the Resource Room are located in Thaw 312, and a detailed schedule is posted here: **https://www.physicsandastronomy.pitt.edu/resource-room-information (https://www.physicsandastronomy.pitt.edu/resource-room-information)** . In addition, tutoring is available through the Academic Support Center (WPU 311). You may also make use of the undergraduate lounge off of the mail room on the second floor of the Old Engineering Hall. This is a good place to meet with classmates to discuss problem sets and course material. You might also meet physics and astronomy majors here that can help you, discuss other classes with you, or inform you about the major program. The Department hosts a donut and coffee hour every Wednesday at 4PM, which is designed to encourage discussion. The Astrophysics group within the Department hosts seminars on topics of current interest in astronomy and astrophysics every other Friday at 11am. The talks are typically at an advanced level, but eager students can learn a great deal about contemporary astronomy and astrophysics by attending (and can obtain credit for doing so). You can find the talk schedule on the Department web site: http://www.physicsandastronomy.pitt.edu.

Academic Integrity

The integrity of the academic process requires fair and impartial evaluation on the part of faculty and honest academic conduct on the part of students. To this end, students are expected to conduct themselves at a high level of responsibility in the fulfillment of their course of study. It is the corresponding responsibility of faculty to make clear to students those standards by which students will be evaluated and the resources permissible for use by students during the course of their study and evaluation. The educational process is perceived as a joint faculty-student enterprise which will perforce involve professional judgment by faculty and may involve - without penalty - reasoned exception by students to the data or views offered by faculty.

Cheating/plagiarism will not be tolerated. Students suspected of violating the University of Pittsburgh Policy on Academic Integrity, from the February 1974 Senate Committee on Tenure and Academic Freedom reported to the Senate Council, will be required to participate in the outlined procedural process as initiated by the instructor. A minimum sanction of a zero score for the quiz or exam will be imposed. For details, refer to the **University Guidelines on Academic Integrity (https://www.provost.pitt.edu/sites/default/files/academic_integrity_guidelines.pdf)** .

Diversity and Inclusion

I consider this class to be a place where you will be treated with respect, and I welcome individuals of all ages, backgrounds, beliefs, ethnicities, genders, gender identities, gender expressions, national origins, religious affiliations, sexual orientations, ability - and other visible and non-visible differences

origins, religious affiliations, sexual orientations, ability - and other visible and non-visible differences. All members of this class are expected to contribute to a respectful, welcoming and inclusive environment for every other member of the class.

Disabilities

If you require special accommodations or classroom modifications, please notify both your instructor and Disability Resources and Services by the end of the first week of the term. The office of Disability Resources and services is located in 140 William Pitt Union, (412) 648-7890, drsrecep@pitt.edu, (412-228-5347 [voice or TDD]), and their website is at **http://www.drs.pitt.edu (http://www.drs.pitt.edu)** . If you have a physical, learning, or emotional disability, please let me know as early as you can so that appropriate accommodations can be made.