Astronomy 4: Black Holes and Cosmic Catastrophes

Fall 2025

Lectures: Monday, Wednesday, 12:30 - 1:45 pm, Kinsey Pavilion 1240B

Discussion Section 1A: Friday, 2:00-2:50 pm, Physics and Astronomy Building (PAB) 2748
Discussion Section 1B: Friday, 3:00-3:50 pm, Physics and Astronomy Building (PAB) 2748
Discussion Section 1C: Friday, 4:00-4:50 pm, Physics and Astronomy Building (PAB) 2434
Homepage: http://www.astro.ucla.edu/∼aes/AST4
BruinLearn Homepage: https://bruinlearn.ucla.edu/courses/213433

Professor:	Alice Shapley
Office:	3-931 PAB
e-mail:	aes@astro.ucla.edu
Office Hours:	Wednesday, 2-3 pm

TA:	Sydney Skorpen
Office:	3-540 PAB
e-mail:	sskorpen@astro.ucla.edu
Office Hours:	Wednesday, TBD; Location: TBD

Text: The Cosmic Perspective, 10th Edition (2023), by Bennett, Donahue, Schneider, & Voit. **Text: Gravity's Fatal Attraction, 3rd Edition (2021)**, by Begelman & Rees. Both of these are included as part of Bruin One Access.

Calculators: A simple one is **highly** recommended, though not required.

1 Introduction

This course introduces students to the exotic cosmic phenomena known as black holes, and their bizarre effects on the very fabric of space and time. Some black holes form in violent events that terminate lives of stars. Other, much more massive black holes live at the centers of galaxies, and their formation story is still mysterious. The course also covers cosmic catastrophes including stellar explosions and mergers, supernovae, and gravitational waves. The course concludes with a discussion of the depiction of black holes in popular culture.

2 Prerequisites

We will review all the basic physical concepts required for understanding the material in the course. However, we expect that students should feel comfortable performing *basic* calculations at the level of high-school algebra and, very occasionally, geometry.

3 Learning Outcomes

Based on based on lectures, and weekly homework and in-class assignments, students will engage in the scientific process of inquiry, analysis, problem-solving, and quantitative reasoning. They will also acquire an informed appreciation of the phenomenology of black holes and gravity in our universe.

4 GE Credit Acknowledgement

Upon successful completion of this course, students will receive credit towards the General Education requirement in the area of Foundations of Scientific Inquiry: Physical Sciences.

5 Grading

Final grades will be based on homework assignments (a total of 8 given during the quarter), discussion-section assignments, the midterm exam, and the final exam. These factors will be combined in the following percentages to determine your class grade:

- 20% homework
- 20% discussion-section assignments
- 30% midterm exam
- 30% final exam

Homework will be assigned roughly every week and is to be turned in online to Gradescope by midnight on the designated day. A total of 8 assignments will be given during the quarter. Late homework may be turned in up to 1 week after the due date. After one week, we will return graded homework and no late assignments will be accepted after that.

Discussion-section assignments will be completed in class during discussion section, and must be turned in at the end of discussion section. There will be a total of 8 discussion-section assignments, and your best 6 discussion-section assignments will be used to calculate your grade for this part of the course.

The midterm exam is scheduled for Wednesday, October 29th, in class. It will test all material covered up to that point, **and will be given during the regular class lecture time.** It will contain a combination of multiple choice, matching, and True/False questions.

The final exam is scheduled for Thursday, December 11th, from 8:00 am - 11:00 am. It will be cumulative, drawing on all material covered in the course, and contain a combination of multiple choice, matching, and True/False questions.

6 Resources

- Midterm and final exams must be completed by the student without assistance and in a manner consistent with standard testing procedures and regulations. Any cheating will be dealt with through the University. We follow the UCLA policies on intellectual integrity, which can be found at: http://www.deanofstudents.ucla.edu/Student-Conduct.

- The UCLA Astronomy division and your professor and teaching assistants are committed to promoting and fostering an inclusive environment to serve our diverse community of learners. Please visit our website at https://www.astro.ucla.edu/diversity-resources.html to learn more about diversity resources and workshops. Our website also lists contact information for allies within the department who are actively working to address diversity issues. If you have questions, concerns, ideas, or feedback, we would love to hear from you.

- Title IX prohibits gender discrimination, including sexual harassment, domestic and dating violence, sexual assault, and stalking. Students who have experienced sexual harassment or sexual violence can receive confidential support and advocacy at the CARE Advocacy Office for Sexual and Gender-Based Violence, which is found on the 1st Floor of the Wooden Center West, CAREadvocate@caps.ucla.edu, (310) 206-2465. You can also report sexual violence or sexual harassment directly to the University's Title IX Office (2241 Murphy Hall) at titleix@conet.ucla.edu, (310) 206-3417.

- CAPS (Counseling and Psychological Services) offers 24-hour crisis counseling via phone (310-825-0768) as well as in-person short-term counseling for all students. Students can walk in Mon-Thurs. 9am - 4pm, Fri. 9am - 3pm and be seen by a Brief Screen Counselor on the same day, who will address immediate needs and determine future care as needed. Please visit www.counseling.ucla.edu for more mental health resources available on campus.

- COVID Policies: Ensuring a safer campus depends on each of us following the latest UCLA health and safety guidelines. While campus policies must be modified to address changing local, state, and national orders and guidance, the current campus protocols are available at https://covid-19.ucla.edu/covid-protocols-at-a-glance/

Schedule of Lectures

No.	Date		Title	Chapter
Week 1:				
1	Sep	29	General introduction. Scale of the Universe. Our place in it.	C1
2	Oct	1	Motion, force & energy.	C4
Week 2:				
3		6	Gravity!	C4
4		8	Light and Thermal Radiation.	C5
Week 3:				
5		13	Matter and Energy Levels.	C5
6		15	The Sun.	C14
Week 4:				
7		20	Measurements of Stars.	C15
8		22	Measurements of Stars.	C15
Week 5:				
9		27	Evolution of Low- and High-mass Stars.	C17
		29	**Midterm Exam, in class**	
Week 6:				
10	Nov	3	End states of stars: White Dwarfs.	C18, C-S4
11		5	End states of stars: X-ray Binaries, Supernova Explosions, Neutron Stars.	C17, C18
Week 7:				
12		10	End states of stars: Pulsars, Black Holes.	C18, G3
13		12	Special Relativity.	C-S2
Week 8:				
14		17	General Relativity and Black Holes.	C-S3
15		19	Observations of Relativity.	C-S2, C-S3
Week 9:				
16		24	The Active Galaxy Zoo: AGNs, Radio Galaxies, and QSOs.	C20, C21, G4, G5, G6
17		26	The Milky Way and Galactic Center.	C19, G4, G8
Week 10:				
18	Dec	1	LIGO and the Event Horizon Telescope.	G10, G11
19		3	Black hole fact and (science) fiction.	
		11	**Final Exam**	

("C"=Cosmic Perspective; "G"=Gravity's Fatal Attraction)