Astronomy 350 CH
The Big Bang, Black Holes, and the End of the Universe
Spring Semester 2023

MWF 10:00–10:50 pm

Course web page URL
`http://go.illinois.edu/astr350ch`

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Office Hours: Wed. 10:50–noon or by appointment

1 Course Goals

Cosmology is science on the grandest of scales. It is one of the hottest areas of research today, weaving together a wide range of disciplines, including observational astronomy, astrophysics, relativity, and the physics of elementary particles and quantum gravity.

At this moment, cosmology is enjoying a golden age in which observation and theory come together to finally settle longstanding questions, but in doing so stumbling upon unexpected and profound new mysteries. We now have an increasingly precise understanding of the scale, shape, motion, and ingredients of the present-day universe. But in detail, we find that most of the matter in the universe must take an exotic form, *dark matter*, unlike anything found in laboratory experiments to date. This startling result points up a fundamental incompleteness in our understanding of elementary particles and their interactions. We are even more staggeringly ignorant as to the nature of the dominant constituent of the universe today, the *dark energy*.

Yet despite these enormous open questions, we can already say a surprisingly great deal about the history of the universe. We have particularly precise and quantitative understanding of what happened just seconds after the big bang: the formation of the most abundant elements in the cosmos and the much later quenching of the cosmic fireball. We are developing a detailed understanding of how tiny variations in cosmic matter across space grow with time to form the structured cosmos of the present day.

In this course, we will survey these topics, and their interrelations. The emphasis will be on cosmology as a centerpiece of modern science. We will develop and then apply scientific principles to understand observations–using the laws of nature measured here and now to reveal what happened "there and then." We will also turn the problem around, and view the universe as a laboratory for fundamental science–using the observed properties of the cosmos to reveal the nature of matter, space, and time on both the grandest cosmic scales and the tiniest subatomic scales. The goal is for ASTR350 alumni to understand the fundamentals of cosmology, and to have knowledge of open questions, and of observational and theoretical tools.

2 Course Requirements and Grading

Grading Scheme

Requirement	Unit Weight	Total Weight
Discussion Questions	10 at 1% each	10%
Homework	8 at 5% each	40%
Presentation		10%
Paper		15%
Midterm		10%
Final Exam		15%

There will be 9 Homework assignments, the best 8 scores will be kept. There will be 11 Discussion Questions, the best 10 scores will be kept. In addition there there is a midterm and a final exam, and a project presented orally and in writing.

This table shows the approximate grading scale in this course. Final course grades will follow these guidelines. Pluses and minuses will be used.
The ranges are approximate in that I may have to adjust them if, for example, I give an exam that is a little too hard. In any case, I will not increase the minimum cutoffs for each letter grade.

Grade	Approximate Range
A	92–100%
B	82–91%
C	72–81%
D	60–71%
F	$< 60\%$

All scores and the final course grades will be posted on the course Canvas page.

3 Course Prerequisites

There are no prerequisites for this course. In particular, you need not have a background in astronomy, physics, or calculus. So if you are not a science major, and/or you do not have a physics or math background, this course is meant for you. But students with a more technical background do take this course, and enjoy it and benefit from it.

Because of the diversity of student backgrounds, the level of the lectures and class discussion cannot at every instant be tuned to the background of every student. Inevitably, there will be some moments (I hope only a few) when either the discussion is not aimed at your level. My intention is to reward your occasional patience with a degree of "customization." That is, the required materials in lecture and in the homework will all be accessible to everyone regardless of background. Some homework assignments will have have options for more or less technical responses. Thus to some degree you can choose how technical you wish the course to be.

4 Readings and Resources

Course Text:

Delia Perlov and Alex Vilenkin *Cosmology for the Curious* (2017) Springer

A large body useful material is available online, and will be useful for homework problems and for researching your report.

5 Discussion Questions

On most Wednesdays, I will post a discussion question on the Discussion Board area of the course Canvas site. There will be 11 Discussion Questions, of which the top 10 scores will be kept.

Answers are due by midnight the next Wednesday. You are responsible for posting at least one substantive, on-topic response to this question or to another student's response to it. These questions generally do not have right or wrong answers, but your response must be substantive (at least one paragraph, and not simply, e.g., "I agree with Pat") and relevant to the posted discussion topic in order to receive credit. Profanity, personal attacks, and other inappropriate posts will be deleted by me and will result in zero.

6 Homework

There will be 9 homework assignments throughout the course. The high frequency is intended to keep you up-to-date on the material. The best 8 scores will be kept, but you are responsible for the material on all homework assignments. Homework is due in class; late homework will be deducted 25% for every calendar day late.

Science is a collaborative enterprise, and you are encouraged to discuss the class material and the problems with your classmates and the instructor. However, you are responsible for your own answers, which you should understand and write up in your own words.

7 Presentation and Paper

You will have the opportunity to focus on a particular topic to develop a deeper understanding. You'll present the topic to the class in a 10-minute talk; this time limit will be enforced strictly. The instructor will give feedback on the talk. Then you will write a paper of around 2000 words ($\approx$ 8 pages) in length, and will draw upon references outside the course text. More details and a list of possible topics will be provided.

8 Exams

There will be one in-class midterm. on Friday Feb 24. Exams will include material covered up to 1 week before the exam date.

There will be a final exam, on Friday May 12, 1:30 to 4:30 pm. The exam is cumulative but with emphasis on material in the later part of the course, and on synthesizing ideas that appear throughout the course.

9 Cosmo-Memes

Cosmology, black holes, and the other topics of the course can be mind-bending. To encourage your efforts to make sense of it all, and for fun, there will be opportunities to

submit memes that will be shared with the class, and that will earn a small amount of bonus credit.

To receive credit your memes must

- be used correctly, as that meme is used in the wild
- engage course content–address ideas, terms, and/or images central to ASTR350
- be appropriate to share with the class

More information will be forthcoming–including the opportunity to win glamourous prizes–but you can start thinking of your memes right away. Have fun!

10 Bonus Points and Participation

Bonus Points: Homework and exams will sometimes include a *bonus* question which is more challenging than the others. Answering these questions gives bonus points in addition to the ordinary point totals. Thus one can view the bonus points as a way to recover points missed on other assignments.

Participation: Participation in class is critical–cosmology is not a spectator sport! The instructor will ask questions frequently – probably it will see *too* frequent! In addition, there will be multiple choice questions in most classes. These are not graded, but are good practice for questions on homework and exams. Moreover, class participation can help your course grade if you are very close to a boundary between letter grades.

Academic Integrity and Collaborative Work

Academic honesty is essential to this course and the University. Any instance of academic dishonesty (including but not limited to cheating, plagiarism, falsification of data, and alteration of grade) will be documented in the student's academic file. In addition, the particular exam, homework, or report will be given a zero.

Guidelines for collaborative work: Discussing course material with your classmates is in general a good idea. However, you are expected to do your own work. **You are responsible for understanding every part of your results and solutions, and for writing these in your own words.** Finally, on exams your work and your answers must of course be entirely your own.

Use of AI Software: Your work for this course should be solely yours, that you have written **in your own words** without aid of AI software .

Accessibility

To insure that disability-related concerns are properly addressed from the beginning, students with disabilities who require reasonable accommodations to participate in this class are asked to see the instructor as soon as possible.