



Image: A zoomed-in region of a map of the distribution of matter made from lensing of the CMB using ACT data, shown against the distribution of emission from dusty star forming galaxies.
From

PHYS 5505

Introduction to Cosmology

Spring 2025 with [Prof. Mathew Madhavacheril](#)

MW 1:45 - 3:15

Location **DRL TBD** (33rd and Walnut St.)

Office hours: TTh 3-4

[How to get to my office](#)

SYLLABUS

This course introduces students to the standard big bang cosmology and the key observations that allow us to test it. It will cover the expanding universe, its thermal history and the study of perturbations. It will explore observational probes of cosmology such as the cosmic microwave background and galaxy surveys. No prior knowledge of astrophysics, cosmology, general relativity, or particle physics will be assumed, although aspects of each will be introduced as part of the course. The course is intended for graduate students and advanced undergraduates.

Prerequisites: Introductory classical, quantum and statistical mechanics

Accommodations

It's important to me that everyone who wants to participate has the [resources](#) to be fully included in this course. Please let me know if you need special accommodations in the curriculum, instruction or assessments of this course to enable you to participate fully. I will make every effort to maintain the confidentiality of the information you share with me.

Penn provides reasonable accommodations to students with disabilities who have self-identified and been approved by [Student Disabilities Services](#) (SDS). If you have not yet contacted SDS and would like to request accommodations or have questions, you can make an appointment by calling SDS at 215-573-9235. The office is located in the [Weingarten Learning Resources Center](#) at Stouffer Commons: 3702 Spruce Street, Suite 300. All services are confidential.

Topics

1. Overview, Introduction and Review of General Relativity
2. The expanding universe, distances and dark energy
3. Thermal history and recombination
4. Initial Conditions and Inflation
5. Newtonian perturbation theory and the growth of structure
6. Relativistic perturbation theory
7. CMB Anisotropies
8. Large-scale structure and baryon acoustic oscillations
9. Weak Lensing

Material

Textbook:

- Cosmology, Daniel Baumann

Evaluation

A letter grade will be assigned based on the following:

1. 70%: Homework assignments
2. 30%: Final take-home exam

COVID Precautions

In order to keep everyone as safe as we can, please respect the following [precautions](#):

- **Get vaccinated.** This is required by Penn for all students, faculty, and staff, with few exceptions.
- **If you feel sick or were exposed to COVID, get a test if possible**
- **If you test positive for COVID, please do not come to class or office hours .**
Specifically, please participate remotely for 5 days after a positive COVID test. Let me know you'll miss class by filing a [Course Absence Notice](#), keep up with the material online, and follow up with me to make up assignments as needed. **Your grade in this class will not be penalized for precautions to protect each other from COVID.**
- **You can rest assured that I will follow similar precautions if I feel sick or were exposed to COVID or test positive for COVID. It is likely that the class will be held remotely on Zoom if this happens.**
- **You are invited to wear a mask in class if you:**
 - want to for any reason
 - are immunocompromised and personally at high risk
 - are in frequent close contact with someone who is high risk
 - tested positive for COVID-19 more than 5 but less than 10 days ago (if less than 5 days, please participate remotely)
 - have been exposed to someone with COVID-19
 - have recently traveled to an area with substantial or high spread of the virus

Please respect the choices of your classmates. If you feel targeted or uncomfortable in class, speak with me.

Academic Integrity

Participants are expected to abide by the [Penn Code of Academic Integrity](#) in letter *and* spirit. Scientific research is a collaborative endeavor that depends on proper acknowledgment of each person's contributions to a project: this holds in this course as it does in general.

Cheating and violations of academic integrity may be reported by the instructor for further disciplinary action. The following in particular should be noted: you may discuss homework questions with others in broad, general terms, but the work you submit should be your own. Giving homework answers to another person or taking them from another person counts as cheating. The homework is meant as practice for the exams, so if you take answers from others, you are not only violating the code of academic integrity, but also making it likely that you will perform poorly in the exams. This doesn't mean you can't work together; you could, for example, solve the problems together at a blackboard, and then go back and re-do the homework individually without copying from the blackboard.

"Creating a supportive environment to enable scientific discourse
... is the responsibility of all participants."

American Physical Society,
Code of Conduct for APS Meetings

Fostering an inclusive atmosphere in scientific discussions is an integral part of academic and professional ethics. Participants are expected to abide by the [Penn Code of Student Conduct](#) during course activities, and to use the following guidelines as a standard of behavior¹:

Expected Behavior

- Be considerate, respectful, and collaborative.
- Critique ideas rather than individuals.
- Avoid personal attacks directed toward other participants.
- Be mindful of your surroundings and of your fellow participants.
- Congratulations on reading this far into the syllabus. Send me an email during the first week of classes with the code PaleBlueDot and I will provide an additional 1% extra credit. Please do not ask for this after Week 1.
- Respect the rules and policies of our online classroom in [Canvas](#) and [Zoom](#).

Unacceptable Behavior

- Harassment, intimidation or discrimination in any form will not be tolerated.
- Physical, verbal, or online abuse of any participant will not be tolerated.
- Examples of unacceptable behavior include, but are not limited to: verbal or online comments related to gender, gender identity and expression, sexual orientation, disability, physical appearance, body size, race, religion, national origin, as well as inappropriate use of nudity and/or sexual images, and threatening or stalking any participant.
- Recording or photographing another individual without their explicit permission is not allowed.

Consequences

- Anyone requested to stop unacceptable behavior is expected to comply immediately.
- The course instructor may take any action deemed necessary and appropriate, including immediate removal from a class session or the course, or referral to university disciplinary procedures.

Reporting Unacceptable Behavior

- If you are the subject of unacceptable behavior or have witnessed any such behavior, please immediately notify the instructor.
- Anyone experiencing or witnessing behavior that constitutes an immediate or serious threat to public safety should contact campus security at **215.573.3333**.

Any member of the Penn community can call the Penn HELP line² at any time to be connected with staff trained for mental health referrals:

215-898-HELP(4357)

¹ Adapted from the [Ecological Society of America meeting code of conduct](#).

² <https://www.publicsafety.upenn.edu/safety-initiatives/help-line-215-898-help/>