

Syllabus:

PY555, Cosmological Physics, Spring 2025

Course description

CAS PY555 provides an introduction to Cosmological Physics intended for advanced undergraduates and graduate students. The first part of the course covers the homogeneous early universe: dynamics of the universe, thermodynamics in the expanding universe with radiation, matter, and vacuum energy, inflation. The second part of the course will cover the inhomogeneous universe. Topics are the growth of density perturbations, the cosmic microwave background, and large scale structure. The course will introduce the cosmological Standard Model and its predictions and observational evidence as well as open questions related to dark matter, dark energy, and neutrinos.

Prerequisites, credits, program outcomes

CAS PY406 and CAS PY408 are required pre-requisites. In exceptional cases they may be waved with consent of the instructor. CAS PY410 is recommended but not required.

4-credits, counts towards the “Elective” requirements for the Physics Major. For graduate students whose primary research is not in cosmology or astro-particle physics it satisfies the “Distribution” requirement.

Instructors

Professor Martin Schmaltz, Email: schmaltz@bu.edu, cell: (617) 780-4509 , Office: PRB 561
Office hours: after lecture or come to PRB 561 anytime, or via ZOOM/Slack

Meeting Times

MWF 2:30-3:20pm, lecture, SOC B57 (100 Cummington Mall) M 3:30-4:20pm, discussion, SOC B57

Website

The course website with problem sets, solutions, lecture notes and supplementary material is
<http://physics.bu.edu/~schmaltz/PY555/>

Grading Policies

Weekly problem sets: 100%. Please hand in your HW solutions to me before class on the due date. Late homework receives no credit except with prior arrangement. Solutions to the problem sets will be provided after the HW is due and graded problem sets will be returned within a week. The assignment on which you received the lowest score will be dropped in the calculation of your course grade.

Course Outline

After an introduction and review of special and general relativity essentials the course will follow Baumann’s notes. Additional background material on relativity and thermodynamics will be inserted as needed.

Part I: The Homogeneous Universe

- I.1 Geometry and Dynamics
- I.3 Thermal History
- I.2 Inflation

Part II: The Inhomogeneous Universe

- II.4 Cosmological Perturbation Theory
- II.5 Structure Formation
- II.6 Quantum Initial Conditions

Suggested Readings

The course is primarily based on the “Cosmology” notes by Daniel Baumann which are also the basis for his excellent textbook “Cosmology” (recommended). Our course also uses some supplementary material from the book “Modern Cosmology” by Scott Dodelson and the “No-Nonsense” GR notes by Sean Carroll. You are not required to purchase any books, but Baumann’s book as well as Dodelson’s are recommended. Useful readings to accompany the course include:

- Daniel Baumann “Cosmology” based on the Baumann notes.
- Scott Dodelson “Modern Cosmology” very readable book at the level of the Baumann notes.
- Mukhanov “Physical Foundations of Cosmology” nice book that is a little more formal than Dodelson.
- Kolb and Turner “The Early Universe” classic that is also quite readable, a little outdated.
- Weinberg “Cosmology” rigorous, but harder to penetrate.
- Schneider “Extragalactic Astronomy & Cosmology”, nice text which is used in Prof Brainerd’s CAS AS413; the Cosmology sections of this book are more elementary.
- Ryden “Introduction to Cosmology”, also elementary but quite good.

Resources/Support/How to succeed in this course

- This is an advanced course and your work in and outside class will be an important part. Do all the homework, read the provided text before and after class, and ask questions during class, discussion, and on Slack.
- Your classmates are a great resource, and working with each other as much as possible can be both fun and helpful in learning the material.
- Take initiative in getting help when you need it. Meeting with students in office hours is both part of my job as well as something I enjoy, take advantage of it.
- Accommodations for students with documented disabilities: If you are a student with a disability or believe that you might have a disability that requires accommodations, please contact the Office of Disability Services (ODS) at (617) 353-3658 or access@bu.edu to coordinate any accommodation requests.
- Accommodations for religious holidays: Students are permitted to be absent from class and examinations for purposes of religious observance. Please inform the instructor before the meetings in question. Missed work shall be made up in consultation with the instructor. All religious observances, within all religious traditions, are subject to this accommodation.

Academic conduct

Students must be familiar with and follow the BU Academic Conduct Code.

<https://www.bu.edu/academics/policies/academic-conduct-code/> for undergraduates

<http://www.bu.edu/cas/students/graduate/grs-forms-policies-procedures/academic-discipline-procedures/> for graduate students.

Cheating on problem sets and the final exam will not be tolerated, and suspected cases will be treated in accordance with BU Academic Conduct procedures. Collaboration at the problem solving stage of the weekly problem sets is allowed and encouraged, but each member of a collaborating group of students should write up and hand in their solutions independently. For questions regarding this policy please see the instructor.