

ASTR540: “Advanced Cosmology”

Units: 3

Instructor: Elena Pierpaoli, pierpaol@usc.edu , SHS 371, tel: (213)740-1117

Office hours: by arrangement

Times and location: Wed-Fri noon-1:50 pm

location GFS113

Updated information about the course: see the blackboard site:

<https://blackboard.usc.edu/>

Teaching Assistant: TBD

Email:

tel: TBD

Office hours: by arrangement

Course description (on line catalog): The Universe: its content and thermal history. Density anisotropies: initial conditions, linear and non-linear evolution. Observables, current and future data, theory-observations comparison.

Expanded Course description:

The course is designed to give basic concepts to second and third year graduate students potentially interested in cosmology or high-energy physics research. The aim of the course is to bring new graduate students at a level that will allow them to comfortably follow a seminar in a broad range of astrophysical topics, and read scientific literature independently.

We will first discuss the unperturbed Universe.

We will show evidences for the expansion, and present the mathematical framework to describe it. We will discuss the content of the Universe, including dark matter and its properties, neutrinos, baryons and photons. We will then present the thermal history of the Universe, including inflation, nucleosynthesis and reionization.

Finally, we will discuss some of the tools that are used to derive cosmological constraints, like the angular diameter and luminosity distance.

In the second part of the course we will discuss the perturbed Universe.

We will show how to derive the relevant equations starting from

Einstein's equations for the metric and Boltzmann's equations for all the species present. We will then discuss the evolution of (linearized) density perturbations through cosmic times, and describe the main observables that can be directly compared to the data (power spectra for matter and radiation, baryon acoustic oscillations).

We will then discuss evolution of density perturbations beyond the linear regime, and introduce some of the currently relevant observables (galaxies and clusters of galaxies, gravitational lensing).

Finally, the course will provide an overview of recent and future surveys in various wavebands that are or will soon be instrumental in shaping our understanding of the Universe. We will discuss their synergies and complementarities, describing current and expected results. We will point out current tensions between probes, as well as open questions.

If time permits, the course will give a general overview of the statistical framework for theory—data comparison in cosmology.

Learning objectives: On completion of the course, students should be able to:

- Describe what are the main evidences in favor of an homogeneous and isotropic expanding Universe.
- Describe how to derive, from first principles, the equations that govern evolution of density perturbations for all relevant components of the Universe.
- Understand the basic ideas of how perturbation are generated in the early Universe and how large-scale structures grow.
- Discuss the relevance of the most significant periods in the history of the Universe (Inflation, Big-Bang Nucleosynthesis, matter-radiation and matter-dark energy equality, recombination)
- Describe the role of different components (dark matter, baryons, radiation) in shaping the observed anisotropies today
- Discuss the main current observational tests of large scale structure and what information they provide on cosmological parameters
- Discuss the role of various current and future surveys in shaping our understanding. Be able to summarize achievements and currently open questions.

Additional general objectives are:

Develop skills for communication of scientific concepts to peers, develop problem solving skills, be able to perform a critical reading of an advanced scientific text in the area of cosmology.

Pre-requisites: Phys504, Phys508ab, Phys510, Phys518

No prior astronomy knowledge is required (it will be built in the course).

Textbook:

We will keep “Modern Cosmology” by Scott Dodelson as the main reference for the theoretical description of linear perturbations and the thermal history of the Universe. For other topics, we will supplement it with various readings from other books and review articles linked to the blackboard webpage.

Grading:

Homework 10%

Classroom worksheets and Interaction: 10%

2 Midterm Exams @ 25% each : 50%

Final presentation of special topic: 30%

Grading type will be letter grade.

In class participation (asking of and answering questions, taking part in discussions, etc.) is strongly encouraged in general, and is in fact expected. Your final grade will take this into account.

General USC grading policies, Incompletes: Please see the “Grading and Correction of Grades” handbook:

http://www.usc.edu/dept/ARR/private/forms/Handbooks/Grade_Handbook_rev082010.pdf

Course Notes: Lectures will mainly be standard blackboard lectures with exercises, but slides, images and videos will be used when appropriate. In such case, they will be posted on the course site. Students are expected to take their own hand-written notes.

Students will need computer access and standard software to access the slides and images/videos in order to study.

Homework policy: There will be 4 homework assignments during the course (approximately one every three weeks). Each assignment is worth 2.5% of the final grade. Typically, assignments consist in standard exercises on what explained in class, but they may also consist in critical reading. The assignments are due at the beginning of the lesson, on the date indicated when the homework is assigned (usually one week after assignment). No late homework will be accepted. I will give indulgences only for really good reasons (sickness—if you have a note from the doctor; death in the immediate family – with a convincing proof; etc.).

Homework should be stapled together and your name should be clearly indicated on the first sheet. Homework with no name will not be corrected.

Exam policy: No late midterms will be accepted. For –very– serious (and proved) health related reasons, special arrangement may be done to make the midterms on a different date. Midterms and final presentation’s dates will be set the first week of classes. Please make sure you schedule your flights home, vacations, etc. accordingly.

You may use a simple (non-programmable) calculator during the written midterms. Midterms will be closed books. There will be a text available on the instructor’s desk for consultation of necessary formulas and constants’ numerical values.

Collaboration policy: NO collaboration is allowed for the midterms. As for the homework, you are encouraged to discuss the problems with other students, but only in general terms, and you have to derive your own solutions. While scientific advancement is based on communication, and therefore you should learn how to communicate your scientific ideas, you should also make sure you do so by following the guidelines for Academic Integrity given below.

Attendance: Grading is also given for attendance and participation. Students are strongly encouraged to attend classes on a regular basis and participate in class work.

The course will offer various opportunities of class participation (discussions, problem solving, quizzes, class Olympiads). These are designed to facilitate students’ learning and optimize the use of your time in learning the material presented.

Should one of the scheduled classes fall on a university holiday, the material scheduled for that class will be made up with an extra class meeting and additional reading.

Communication policy: Students are welcome to contact the instructor by email or in person for any issue. Please allow for up to a full working day in order to receive the reply. Students are encouraged to look on the course website or ask other colleagues information relative to material covered during missed classes and relative assignments.

Classroom policy: Electronic communication devices (phones, blackberries, and similar) must be turned off or placed away during lectures and laboratories. You can check them at the break. Likewise, you should not use instant messenger or similar chat programs during lectures or labs.

Statement for Students with Disabilities: Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered

to me (or to TA) as early in the semester as possible. DSP is located in STU 301 and is open 8:30 a.m.–5:00 p.m., Monday through Friday. Website and contact information for DSP:

http://sait.usc.edu/academicsupport/centerprograms/dsp/home_index.html, (213) 740-0776 (Phone), (213) 740-6948 (TDD only), (213) 740-8216 (FAX) ability@usc.edu.

Statement on Academic Integrity: USC seeks to maintain an optimal learning environment. General principles of academic honesty include the concept of respect for the intellectual property of others, the expectation that individual work will be submitted unless otherwise allowed by an instructor, and the obligations both to protect one's own academic work from misuse by others as well as to avoid using another's work as one's own. All students are expected to understand and abide by these principles.

Plagiarism – presenting someone else's ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Part B, Section 11, "Behavior Violating University Standards" policy.usc.edu/scampus-part-b. Other forms of academic dishonesty are equally unacceptable. See additional information in SCampus and university policies on scientific misconduct, policy.usc.edu/scientific-misconduct.

Student Ombudsman All courses in the Department of Physics & Astronomy have an assigned Student Ombudsman to serve students as a confidential, neutral, informal, and independent resource when they wish to discuss issues concerning their course without directly confronting their instructor. The Student Ombudsman for this course is:

Krzysztof Pilch, pilch@usc.edu, 213-740-1145, SSC 202

Emergency Preparedness/Course Continuity in a Crisis: In case of a declared emergency if travel to campus is not feasible, USC executive leadership will announce an electronic way for instructors to teach students in their residence halls or homes using a combination of Blackboard, teleconferencing, and other technologies.

Support Systems:

Counseling and Mental Health - (213) 740-9355 – 24/7 on call

studenthealth.usc.edu/counseling

Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

National Suicide Prevention Lifeline - 1 (800) 273-8255 – 24/7 on call

suicidepreventionlifeline.org

Free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week.

Relationship and Sexual Violence Prevention Services (RSVP) - (213) 740-9355(WELL), press "0" after hours – 24/7 on call

studenthealth.usc.edu/sexual-assault

Free and confidential therapy services, workshops, and training for situations related to gender-based harm.

Office of Equity and Diversity (OED) - (213) 740-5086 / Title IX – (213) 821-8298

equity.usc.edu, titleix.usc.edu

Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants.

Reporting Incidents of Bias or Harassment - (213) 740-5086 or (213) 821-8298

usc-advocate.symlicity.com/care_report

Avenue to report incidents of bias, hate crimes, and microaggressions to the Office of Equity and Diversity | Title IX for appropriate investigation, supportive measures, and response.

The Office of Disability Services and Programs - (213) 740-0776

dsp.usc.edu

Support and accommodations for students with disabilities. Services include assistance in providing readers/notetakers/interpreters, special accommodations for test taking needs, assistance with architectural barriers, assistive technology, and support for individual needs.

USC Campus Support and Intervention - (213) 821-4710

campussupport.usc.edu

Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

Diversity at USC - (213) 740-2101

diversity.usc.edu

Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

USC Emergency - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call

dps.usc.edu, emergency.usc.edu

Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

USC Department of Public Safety - UPC: (213) 740-6000, HSC: (323) 442-120 – 24/7 on call

dps.usc.edu

Non-emergency assistance or information.

