Astronomy 8873: Cosmology and Structure Formation

Course Objectives

This course is a graduate-level introduction to astrophysical cosmology, with emphasis on the “standard” big bang theory of the universe and, in the latter part of the course, its extension to a more detailed theory (the inflation + cold dark matter + cosmological constant model) that is presently the leading scenario for explaining the origin of structure in the universe. The course is intended to give you the background needed to (a) read the current research literature, (b) get started on research in cosmology if you wish to do so, and (c) understand the current issues and debates in the field.

Course Outline

We will devote roughly half of the course to the description of the large scale, homogeneous universe (Part I below) and half to topics in structure formation (Part II below). The individual topics listed below will occupy 1-3 lectures apiece. The challenge for me in teaching the course is to go quickly enough through the material in Part I to have time for the topics in Part II.

INTRODUCTION: observational and theoretical basis of the standard model

PART I: THE HOMOGENEOUS UNIVERSE
A minimal sketch of general relativity
Homogeneous cosmological models (the Friedmann-Robertson Walker universe)
Thumbnail sketch of cosmic history
The cosmic microwave background
Primordial nucleosynthesis
Horizons and inflation

PART II: THE INHOMOGENEOUS UNIVERSE
Perturbation theory
Non-linear collapse and dark matter halos
The cold dark matter paradigm
The cosmic expansion history and dark energy
Microwave background fluctuations
Large-scale structure
Galaxy formation

Readings

When I have taught this course in the past, I have never found a textbook that I considered ideal for the purpose. Barbara Ryden’s *Introduction to Cosmology* is outstanding, and well worth owning and reading if you didn’t already encounter it as an undergraduate. However, the graduate level textbooks tend to focus on subsets of the topics I want to cover and to do so at a level that is more technical than we have time or inclination to pursue in this course.

The new textbook by Dragan Huterer, *A Course in Cosmology: From Theory to Practice*, is, finally a book that is well tuned to the graduate cosmology course I want to teach. There is more in this book than we will have time to cover, and the treatment of some early universe topics is more technical than the level we will adopt in class. However, the book will be a valuable complement to the lectures, and the course should take you far enough that you can follow the book for material we do not get to in class.

Other textbooks that I have found useful in learning and teaching cosmology are:

Kolb and Turner, *The Early Universe*

Padmanabhan, *Structure Formation in the Universe*

Peacock, *Cosmological Physics*

Peebles, *Principles of Physical Cosmology*

In previous incarnations of the course I have assigned readings from different sections of these books on different topics, but I think Huterer's coverage is good enough that we won't need these supplementary readings. I list the books here because they are classics in the field that you should be aware of. Each of Huterer's chapters ends with Bibliographical Notes that provide good pointers to further reading, sometimes from these books.

I will assign some readings from journal articles throughout the course. Although the retrospective treatment of a topic in a textbook is usually easier to follow, journal articles allow you to see ideas as they develop. Since our job as researchers is to develop new ideas, it is valuable to see ideas that are now fully established during their nascent phases.

Assignments and Grading

Other than reading, the course assignments will be six (± 1) problem sets and a take-home final exam. I may add some short questions in weeks when there is not a problem set.

The problem sets are an essential component of the course. They take you through calculations that I have found valuable to my own understanding of cosmology. You should allot 8 hours to a problem set, and if you haven't finished in that time you should write up what you have and turn it in. I care about you putting in a serious effort on each problem set, but I don't expect you to get through every part of every one.

If you are aiming to become a professional cosmologist, a lot of the end-of-chapter problems in the Huterer book look quite good. If I had time to attempt them all, I would.

Formally, the course grade will be based 60% on the problem sets, 20% on the final exam, and 20% on class participation. However, you should focus your attention on learning the material. If you put reasonable effort into class, the homework, and the final, your grade will take care of itself.

Web Page

The course web page is
`http://www.astronomy.ohio-state.edu/ dhw/A8873/a8873.html`.

When material shouldn't be in the public domain, I will distribute it through Carmen. However, for the most part I will use the web page for posting course material.