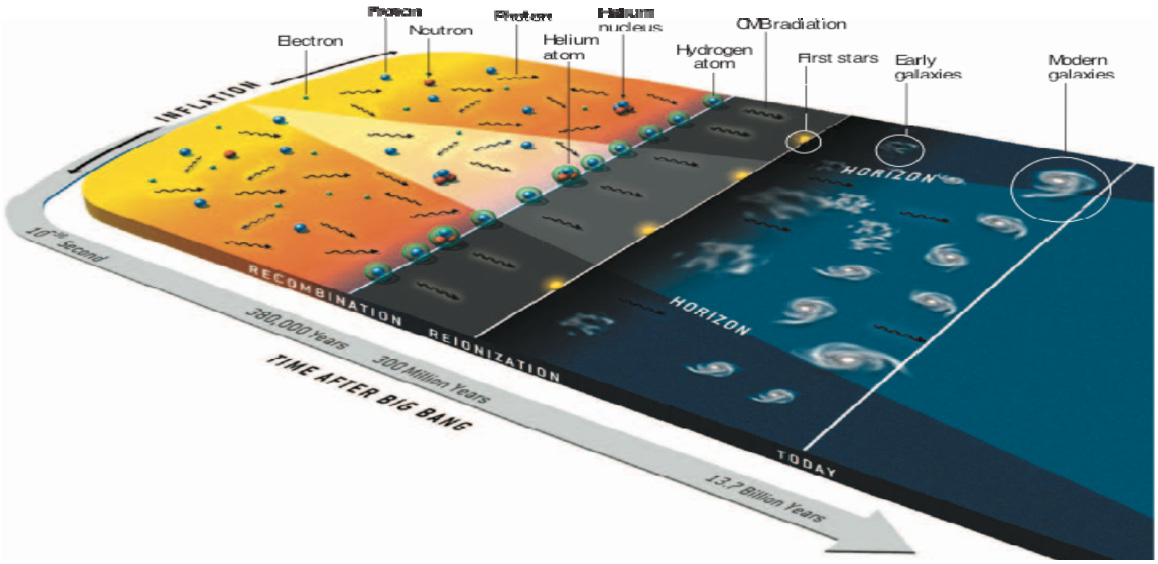
PHYS 581-001 Advanced Topics: Cosmology
Spring 2010



This class is a full 3 credit course and can serve as a A481 elective for undergraduates.

Instructor: Rouzbeh Allahverdi
Time and Location: T R 12:30-13:45, Physics and Astronomy Room 5

Book(s):
None required but below is a list of books that I will use as references. I will try to put as many of these on reserve at the Centennial Library.
- **The Early Universe** (by Kolb and Turner)
- **Cosmology** (by Weinberg)
- **Physical Cosmology** (by Peebles)
- **Cosmological Physics** (by Peacock)
- **Structure Formation in the Universe** (by Padmanabhan)

Requisites:
Undergrads: 301 (Thermo), 405 (E&M), and 491 (QM)
Graduate Students: I'm assuming you are at or above the level of the courses listed above.

Grading Policy:
The final grade will consist of equal contributions from the following three things:
a) Homework assignments (approximately 6-7 sets)
b) A midterm exam
c) A final project involving a term paper and a presentation

Preliminary outline:

The influx of high quality data made possible by advances in technology has revolutionized cosmology over the past two decades. The goal of this course is introduce students to modern cosmology and its observational and theoretical pillars. A list of main topics that will be covered in this course includes:

- **Friedman-Robertson-Walker Universe.** We will begin by postulating that the Universe is isotropic and homogeneous. According to Einstein's theory of general relativity such a universe is described by the Friedman-Robertson-Walker metric. This is the main theoretical pillar of the hot big-bang cosmology. We will examine the various allowed FRW universes that can result. We will also see that according to the big-bang model the Universe was essentially a hot soup of elementary particles at early times.

- **Big Bang Nucleosynthesis (BBN).** This is one of the observational pillars of the hot big-bang cosmology. It also provides us with the earliest direct probe of the early universe (when the Universe was about one second old). We will describe the epoch in the early universe when protons and neutrons are made into light elements (up to lithium 7). We will compare the primordial abundances of the light elements, as predicted by the BBN, with data and find constraints on the baryon density of the Universe.

- **Cosmic Microwave Background Radiation (CMB).** This is another observational pillar of the big-bang model. The properties of the CMB (temperature, anisotropies, etc) are among the most precisely measured quantities of the early universe. We will discuss, at various levels of detail, the physics of the CMB epoch (when the Universe was about 300,000 years old). We will see that the CMB data provide independent constraint on the baryon density that is in concordance with the BBN prediction.

- **Structure Formation.** During this part we will attempt to connect the early universe constraints from the CMB and BBN to what we observe today: galaxies, clusters of galaxies, superclusters, etc. Using the Newtonian approximation, we will see how tiny density fluctuations are amplified as a result of gravitational clumping. We will also see the evidence for and constraints on the dark matter from structure formation.

- **Special Topics.** Time permitting, we will discuss topics of the very early universe. These include: dark matter (various lines of evidence for missing matter in the Universe, WIMP dark matter and its production), baryogenesis (matter-antimatter asymmetry in the Universe, creation of baryon asymmetry), inflation (the isotropy and flatness problems of the hot big-bang model, inflation as a dynamical solution and the source of primordial density perturbations).