

**AST 396C/PHY394T Syllabus**  
**Fall 2014**

<b>Course Title:</b>	“Elements of Cosmology”
<b>Course Number:</b>	AST 396C (Unique No. 48680) PHY 394T (Unique No. 58375)
<b>Hours:</b>	Tu, Th 11:00 - 12:30 p.m.
<b>Location:</b>	RLM 5.104
<b>Textbooks:</b>	Weinberg, S. 2008 <i>Cosmology</i> (Oxford University Press)
<b>Exams:</b>	None
<b>Homework:</b>	(1) Problem sets will be assigned. (2) One end-of-semester student lecture on a topic selected in consultation with the professor, with lecture notes handed in.
<b>Grading:</b>	Course grade will be based upon the problem sets and student talk/lecture notes.
<b>Instructor:</b>	Professor Paul R. Shapiro Office: RLM 16.204 Phone: 471-9422 Email: shapiro@astro.as.utexas.edu Office Hours: after class or by appointment
<b>Prerequisites:</b>	Suitable for all beginning or advanced graduate students in astronomy or physics. Previous course in cosmology not required.

**AST 396C/PHY 394T  
Elements of Cosmology**

**OUTLINE**

Part I. The Background Universe: A Summary of Standard, Homogeneous Big Bang Cosmology

1. Newtonian Cosmology and the Friedmann Models
  - 1.1 Newtonian Fluid Equations and Poisson's Equation
  - 1.2 The Cosmological Principle: Homogeneity and Isotropy
  - 1.3 Universal Expansion
    - 1.3.1 Scale Factor and Hubble Constant
    - 1.3.2 Hubble Expansion Law
  - 1.4 Dynamics of Hubble Expansion and the Matter Content of the Universe
    - 1.4.1 Evolution of  $H(t)$
    - 1.4.2 Density Parameter:  $\Omega$
    - 1.4.3 Deceleration Parameter:  $q$
    - 1.4.4 Matter-Dominated Models: Open, Closed, and Einstein-de Sitter
    - 1.4.5 The Effect of a Cosmological Constant
2. Relativistic Cosmology: the Friedmann-Robertson-Walker Universe
  - 2.1 Robertson-Walker Metric
  - 2.2 Redshift
  - 2.3 Distance and Angles in a FRW Universe
    - 2.3.1 Luminosity Distance
    - 2.3.2 Angular Diameter Distance
  - 2.4 Number Counts
  - 2.5 Friedmann Equations and the Friedman Models
  - 2.6 Age of the Universe
    - 2.6.1 Hubble Expansion Age
    - 2.6.2 Direct Age Estimates
3. Thermal History of the Universe: The Big Bang
  - 3.1 Radiation- vs. Matter-Dominated Epochs
  - 3.2 Overview of Thermal History
  - 3.3 Microscopic Distribution Functions and Equilibrium Thermodynamics in the Early Universe
  - 3.4 Coupled vs. Decoupled Species
  - 3.5 Big Bang Nucleosynthesis

#### 4. The Cosmic Microwave Background (“CMB”)

##### 4.1 The Planck Spectrum and its Distortion

##### 4.2 Anisotropy

#### 5. Mass-Energy Content of the Universe

##### 5.1 Dark Matter

##### 5.2 Baryons

##### 5.3 Radiation

##### 5.4 The Cosmological Constant

### Part II. Structure in the Universe

#### 6. Overview

##### 6.1 Galaxies, Clusters, and Large-Scale Structure

##### 6.2 The Intergalactic Medium and Quasar Absorption-Line Gas

##### 6.3 Dark Matter

##### 6.4 The Cold Dark Matter Model

#### 7. Gravitational Instability and the Formation of Galaxies and Large-Scale Structure

##### 7.1 Linear Perturbations and the Growth of Primordial Density Fluctuations

##### 7.2 The Simplest Nonlinear Model: Spherical Top-Hat Density Perturbations

##### 7.3 Self-Similar Spherical Infall

##### 7.4 Cosmological Pancakes

##### 7.5 Gaussian Random Noise Initial Conditions and the Primordial Power Spectrum

##### 7.6 Dark-Matter-Dominated Models (e.g. Cold Dark Matter)

##### 7.7 Observational and Theoretical Constraints on the Initial Conditions

###### 7.7.1 CMB Anisotropy

###### 7.7.2 Galaxy Clustering and Peculiar Motions

##### 7.8 Approximate Methods

###### 7.8.1 Press-Schechter Approximation

###### 7.8.2 Zel’dovich Approximation

##### 7.9 Testing Models: Numerical N-Body Simulations of Galaxy and Large-Scale Structure Formation

#### 8. Gas Dynamics, Galaxy Formation, and the Intergalactic Medium

##### 8.1 Supercomoving Variables and the Fluid Conservation Equations

##### 8.2 Linear Perturbations and the Baryon Jeans Mass

##### 8.3 Self-Similar Spherical Infall

- 8.4 Cosmological Pancakes
- 8.5 Galactic Explosions and Intergalactic Blast Waves
- 8.6 Cosmological H II Regions and the Reionization of the Universe
- 8.7 The Postcollapse Equilibrium Structure of Galaxies and Clusters
  - 8.7.1 Virial Equilibrium and Isothermal Spheres
  - 8.7.2 Universal Mass Profiles
  - 8.7.3 Comparison of Theory and Observation
- 8.8 The Origin of Galactic Rotation
- 8.9 The Lyman Alpha Forest: Quasar Absorption Lines from Intergalactic Gas
- 8.10 Primordial Star Formation
- 8.11 Testing Models: Numerical Gas Dynamics Simulations of Structure Formation
  - 8.11.1 Lyman Alpha Forest Quasar Absorption-Line Gas
  - 8.11.2 Galaxy Formation
  - 8.11.3 X-Ray Cluster Formation
  - 8.11.4 Cosmic Reionization