

**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: Ω
 - 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