Professor Paul R. Shapiro Spring 2013

AST 396C/PHY 394T
Elements of Cosmology

OUTLINE

Part I. The Background Universe: A Brief 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 Brief Preview of 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 Conservations Equations

    8.2 Linear Perturbations and the Baryon Jeans Mass

    8.3 Self-Similar Spherical Infall