

16 : THE COSMOLOGICAL FRAMEWORK

(16.1) Introduction

- (a) The Good News
- (b) The Not-So-Good News
- (c) Our Path Through the Subject

(16.2) Global Properties

- (a) Large Scale Isotropy
- (b) The Cosmological Principle
- (c) Large Scale Homogeneity
- (d) Small Scale Structure
- (e) Expansion
 - (i) The Hubble Law
 - (ii) Everyone Sees the Same Law
- (f) The Big Bang
- (g) Cosmic Time
- (h) Olber's Paradox

(16.3) More on Expansion

- (a) Expanding Coordinate Grids
- (b) Scale Factor $a(t)$ & Comoving Coordinates
- (c) Hubble Parameter: $H(t)$
- (d) Velocity Distance Relation & Hubble Law
- (e) The Hubble Sphere
- (f) The Nature of the Redshift
- (g) Measuring Distances and H_0

(16.4) Components & their Densities & Pressures

- (a) The Stage and its Contents
- (b) Critical Density & Spatial Geometry
- (c) Pressure & Equations of State
- (d) The Five Components
 - (i) Dark Energy
 - (ii) Dark Matter
 - (iii) Baryons
 - (iv) Photons
 - (v) Neutrinos
- (e) Density Changes with Scale Factor
- (f) Rates of Expansion ($k=0$, single component)
- (g) Cosmic Cooling
 - (i) Photon (& Neutrino) Cooling
 - (ii) Matter (& Galaxy) Cooling
- (h) The Peculiar Role of Negative Pressure

(16.5) Cosmic Geometry: Robertson-Walker Metric

- (a) Space-Time Geometries
 - (i) Example 1: "Flat" Geometry
 - (ii) Example 2: Uniform Positive Curvature

- (iii) Example 3: Uniform Negative Curvature
- (iv) Adding Time
- (v) Geodesics
- (b) The Robertson-Walker Metric
- (c) Simple Properties of the RW-Metric
 - (i) Proper Time
 - (ii) Proper Distance
 - (iii) Velocity Distance Law
 - (iv) Time Dilation & Redshift
 - (v) Total Cosmic Volume

(16.6) Cosmic Dynamics: the Friedmann Equation

- (a) Gravity's Field Equation
 - (i) From Scaler to Vector to Tensor
 - (ii) $T_{\mu\nu}$: The Energy-Momentum Tensor
 - (iii) $G_{\mu\nu}$: The Curvature Tensor
 - (iv) Two Cosmological Equations
 - (v) A Newtonian Analog
- (b) Cosmological Parameters
 - (i) Hubble: H
 - (ii) Density: ρ , Ω
 - (iii) Curvature: R_0
 - (iv) Deceleration: q
 - (v) Cosmological Constant : Λ
- (c) The Many FRW World Models
 - (i) The General Case
 - (ii) The Concordance Model
 - (iii) Flat Models: Single Component
 - (iv) Flat Models: Matter + Vacuum
 - (v) Curved Models: Single Component
 - (vi) Specific & Named World Models
 - (vii) Convergence to Flatness

(16.7) Horizons & Distances

- (a) Three Proper Distances
 - (i) Two Examples: $z = 6$ & 1000
- (b) Horizons
 - (i) The Hubble Sphere
 - (ii) The Particle Horizon
 - (iii) The Event Horizon
- (c) Space-Time Diagrams
- (d) Energy within the Horizon

(16.8) Observables vs Redshift: A Toolkit

- (a) Luminosity Distance
- (b) Angular Diameter Distance
- (c) Proper Motion Distance
- (d) Surface Brightness
- (e) Volumes of Shells
- (f) Summary of Relations

(g) Useful Charts

(16.9) Classical Tests

(16.10) Classic Problems

(16.11) Inflation

(16.12) Early Universe

(16.13) Recombination & The CMB