

## 1 Standard Model of Cosmology

- Census of the contents of the universe
- Hierarchical Distribution of Galaxies, basic scales and sizes (e.g. how large are galaxies? Clusters?)
- Defining characteristics of the standard model (Cosmological Principle, Expansion, etc.)
- Observational support for the standard model (Olbers' paradox, Hubble expansion, Cosmic Microwave Background, Big Bang Nucleosynthesis)

## 2 Newtonian Gravity

- Newton's laws, and subtleties in their application to the Universe as a whole
- You should be able to derive the Friedmann Equation in Newtonian theory

## 3 Friedmann Equation

- Re-interpretation of the Newtonian equation in General Relativity (energy vs. curvature, mass vs. energy)
- Metrics and the interpretation of the scale factor  $a(t)$
- Complements of the Friedmann Equation: fluid equation, equation of state
- Be able to solve for simple cases, such as a single-component Universe
- Be able to derive age of the universe for a single-component Universe

## 4 Constituents of the Universe

- Know the various components and their relative importance as a function of redshift
- Basic properties of black-body radiation (Planck spectrum, energy density, etc)
- Know how we measure contribution of each component to present-day energy density
- Know the value of the equation of state  $w$  of each component
- Various ways to measure amount of dark matter (know basic ideas and equations)

## 5 Properties of the Expanding Universe

- Meaning of the general relativistic metric - understand metric of positively curved space-time in terms of analogy with surface of a sphere
- Understand conversions between scale factor  $a$ , redshift  $z$ , and cosmic time  $t$ .
- Be able to derive the cosmological redshift  $z$ , understand difference from Doppler shift
- Understand definition and meaning of different distances (angular diameter distance, luminosity distance, coordinate distance, proper distance), be ready to derive them (as a function of redshift) in simple cosmologies

## 6 Measuring Cosmological Parameters

- understand the basic idea of the various methods we discussed, based on age of the universe, distances (angular diameter vs. luminosity distance), cosmic volume per unit redshift, gravitational lensing, etc.
- be aware of the main observational challenges (finding accurate standard candles, unevolving populations of objects, etc.)

## 7 Miscellaneous

- Basic trigonometric identities ( $\sin^2 \theta + \cos^2 \theta = 1$ , etc)
- Astronomical units conversions (radian to arcmin, 1/s to km/s/Mpc, etc)
- Basic calculus (derivatives, integrals, chain rule, finding maximum of a function, etc)
- Simple differential equations (power-laws, exponentials)