PGRE Astro

Likely Topics

- Redshift
- Hubble’s Law
- Blackbody radiation

Scale Factor

- a(t) is the scale factor of universe expansion
- Universe is homogeneous and isotropic at large scales
- ds^2 is the space-time metric
- The distance between spacelike separated points grow with time

$$ds^2 = dt^2 + a(t)^2(dx^2 + dy^2 + dz^2)$$

Redshift

- Caused by expansion of space
- a(t) is scale factor
  - Always defined today as 1
  - Increasing function as t increases
  - T < t, therefore a(T) < 1
- z(t) is the redshift

$$\frac{\lambda_0}{\lambda_T} = \frac{a(today)}{a_T}$$

$$z(T) = \frac{\lambda_0}{\lambda_T} - 1$$

Hubble's Law

$$v = H_0 d$$

- Linear
- Equation relates recessional velocity of galaxies with distance from us
- If a galaxy is twice as far away, it appears to be moving twice as fast
- Hubble's constant is not constant or known

$$H_0 = 68 \pm 2 \frac{km}{s\ Mpc}$$

Blackbody Radiation

$$\lambda_{max} \propto \frac{1}{T}$$

- Comes from Wein's Displacement Law
- If universe expands by two, blackbodies cool of by a factor of two
- Cosmic Microwave Background
  - 2.7 K
  - Best approximation of a blackbody every seen
  - Provides clear evidence for Big Bang

Dark Matter

- Unknown what makes up dark matter
- Not black holes, not literally dark
- Most likely candidate are WIMPs, interact with weak nuclear force

Example Problem

What does Hubble's constant define?

a. The magnitude of the red-shift of light from a galaxy
b. The expected distance to a galaxy
c. The rate at which space is expanding for all time
d. The rate at which space is expanding today
e. None of the above

Practice Problem

If at some point in the future, a(T) = 2, what is the temperature of the cosmic microwave background at this time?

a. 2.7 K
b. 1.35 K
c. 5.4 K
d. 0.675 K
e. 1.15 K