Lecture 17: Selected Powerpoint Slides

A “Real” Supernova Hubble Diagram

(data from Riess et al. 2004)

Luminosity Distance

Present **proper distance** \((d_p)\): “Tape measure” distance of an object, today.

Present **luminosity distance** \((d_L)\): Distance we infer based on flux received.

By definition: \( F = \frac{L}{4\pi d_L^2} \)

Thus: \( d_L = \left( \frac{L}{4\pi F} \right)^{1/2} \)

Incorporating effects of **cosmological redshift** and **cosmological time dilation**:

\[ F = \frac{L}{4\pi \omega^2 (1+z)^2} \]

Thus: \( d_L = \omega (1+z) \) or \( \omega = \frac{d_L}{1+z} \)

Note: \( \omega \) = present coordinate distance of object. This equals the present proper distance iff space is flat.
**Angular Diameter Distance**

The distance, $d_A$, estimated to an object of proper length $D$ that subtends an angular diameter $\theta$ according to:

$$ d_A = \frac{D}{\theta} $$

**Matter Only**

$$ d_A = \frac{\varpi}{1+z} $$

Note: $d_A = \frac{d_L}{(1+z)^2}$

**Matter + Lambda**

For $k=0$:

As $z \to \infty$, $\varpi \to d_{h,0}$. Thus, for high $z$:

$$ d_A \approx \frac{d_{h,0}}{z} \approx \frac{14.6 \text{ Gpc}}{z} $$

(Fig. 15.30)

For concordance cosmology

**Proper Distance at the Time of Observation and Emission of Photons**

For $\Omega_m = 1, \Omega_\Lambda = 0$:

$$ d_{p,0}(z) = \frac{2c}{H_0} \left( 1 - \frac{1}{\sqrt{1+z}} \right) $$

(Ryden, Fig. 6.6)