Luminosity Distance

The most fundamental distance scale in the universe is the Luminosity Distance,

Luminosity Distance: $d_L = (L/4\pi f)^{1/2}$

where f is the observed flux (sun = 1368 W/m^2) of an astronomical object and L is its luminosity.

In relativistic cosmologies, observed flux (bolometric, or in a finite bandpass) is:

$$f = L/\left[(4\pi D_L^2)(1+z)^2\right]$$

One factor of (1 + z) is due to the energy loss of photons, and one is due to the time dialation of the photon rate.

A **luminosity distance** is defined as $D_L = D\,(1 + z)$, so that $f = L/(4\pi D_L^2)$.

For a specific flux, however,

$$S_\lambda = \frac{1}{(1+z)} \frac{L_{\lambda/(1+z)}}{L_\lambda} \frac{L_\lambda}{4\pi D_L^2}$$

As shown by Terrell the luminosity distance and absolute magnitudes can be written for each case of the deceleration parameter (q_0) and is often expressed as:
"*The luminosity distance equation in Friedmann cosmology*", Terrell, James

$$E(z, \Omega_r, \Omega_m, \Omega_\Lambda, \Omega_k) := \sqrt{\Omega_k \cdot (1+z)^2 + \Omega_m \cdot (1+z)^3 + \Omega_r \cdot (1+z)^4 + \Omega_\Lambda}$$

Luminosity Distance (Model Dependent)

$$\Omega_K(\Omega_r, \Omega_m, \Omega_\Lambda) := 1 - \Omega_r - \Omega_m - \Omega_\Lambda$$

$$\Omega_K(0, 0.05, 0) = 0.95$$

$$\Omega_K(0, 0.2, 0.8) = 0$$

$$\Omega_K(0, 1, 0) = 0$$

$$d_L(z, \Omega_r, \Omega_m, \Omega_\Lambda, \Omega_k) := (1+z) \cdot \int_0^z \frac{1}{E(z, \Omega_r, \Omega_m, \Omega_\Lambda, \Omega_k)}\, dz$$