Redshift

ASTR 250

λ_{obs} = observed wavelength

λ_{em} = emitted wavelength in rest frame of the object

$$Z = \text{redshift} \equiv \frac{\Delta\lambda}{\lambda_{em}} = \frac{\lambda_{obs} - \lambda_{em}}{\lambda_{em}}$$

NOTE:
$$Z = \frac{\lambda_{obs}}{\lambda_{em}} - 1$$

$$1 + Z = \frac{\lambda_{obs}}{\lambda_{em}}$$

In general, there are 3 main sources to redshifts:

(1) Doppler shift due to "peculiar velocities"

$$1 + Z = \frac{\lambda_{obs}}{\lambda_{em}} = \sqrt{\frac{1+\frac{V}{c}}{1-\frac{V}{c}}}$$

NOTE: in relativity "$\frac{V}{c} \equiv \beta$"...

Special relativity for motion purely along line of sight

Note for $\boxed{V \ll C}$ we can Taylor expand

$$\left(1+\frac{V}{c}\right)^{1/2} \sim 1 + \frac{1}{2}\frac{V}{c} + O\left(\frac{v^2}{c^2}\right) \cdots$$

$$\left(1-\frac{V}{c}\right)^{-1/2} \sim 1 + \frac{1}{2}\frac{V}{c} + O\left(\frac{v^2}{c^2}\right) \cdots$$

$$1 + Z = \left(1+\frac{V}{c}\right)^{1/2}\left(1-\frac{V}{c}\right)^{-1/2} \sim \left(1 + \frac{1}{2}\frac{V}{c}\right)\left(1 + \frac{1}{2}\frac{V}{c}\right)$$

$$\sim 1 + \frac{V}{c} \quad \Rightarrow \quad V \sim c \cdot Z$$

(2) Gravitational redshift - Can be observed in strong gravitational field.

$$\frac{\nu_{obs}}{\nu_{em}} = \sqrt{1 - \frac{2GM}{c^2 R}}$$

General relativity for a non-rotating metric

(3) Cosmological redshift due to expansion of spacetime.

Hubble Law $V = H_0 \cdot D$

and $1 + z = \dfrac{a_{now}}{a(t)}$ ← "scale factor" that is a fundamental measure of length in spacetime.

we will talk about this in detail next class...