Doppler Shift in Light

When we observe the emission or absorption spectra of stars in the universe, we observe their spectral lines to be shifted. This is a consequence of *relativistic* doppler effect in light coming from the stars. If the source is moving away from us, the wavelength of the radiated radiation is observed to longer than at the time it was radiated, and the radiation is said to be *redshifted*. Whereas, if the source is moving towards us, the wavelength of the radiation is observed to be shorter than at the time it was radiated, and the radiation is said to be *blue shifted*. Astronomers encapsulate the redshift of incoming radiation by a single number z.

$$z = \sqrt{\frac{c+v}{c-v}} - 1$$

,where c is the velocity of light and
v is the recession velocity of the source.
For low recessional velocities, the expression of redshift can be approximated as :

$$z = \frac{v}{c}$$

The recession of velocity of a source is the rate at which the source recedes from the observer as a result of the expansion of the universe. Apart from playing an important role in broadening of spectral lines, doppler shift in light is used to measure distance to stars. This can be done using the Hubble's Law. In 1929, Edwin Hubble gave the first inconvertible proof that their galaxies outside the Milky Way. Hubble discovered, that the galaxies are not only moving away from us, but their velocity of *recession* is directly proportional to their distance from us, and this proportionality is encapsulated by the Hubble's Constant H_0.

$$v = H_0 d$$

where, v is the recessional velocity of the star
H_0 is the Hubble's Constant = 70 (km/s)/Mpc, and
d is the distance between the source and the observer.

Therefore, by observing the redshift of spectral lines in emission and absorption spectra, we can find distance to the stars. Some important spectral lines like the *21 cm line* and the H_α line are often used in such calculations. These lines are discussed in a separate section.