LECTURE 5

ASTROPHYSICS

Distances and Stellar Motion

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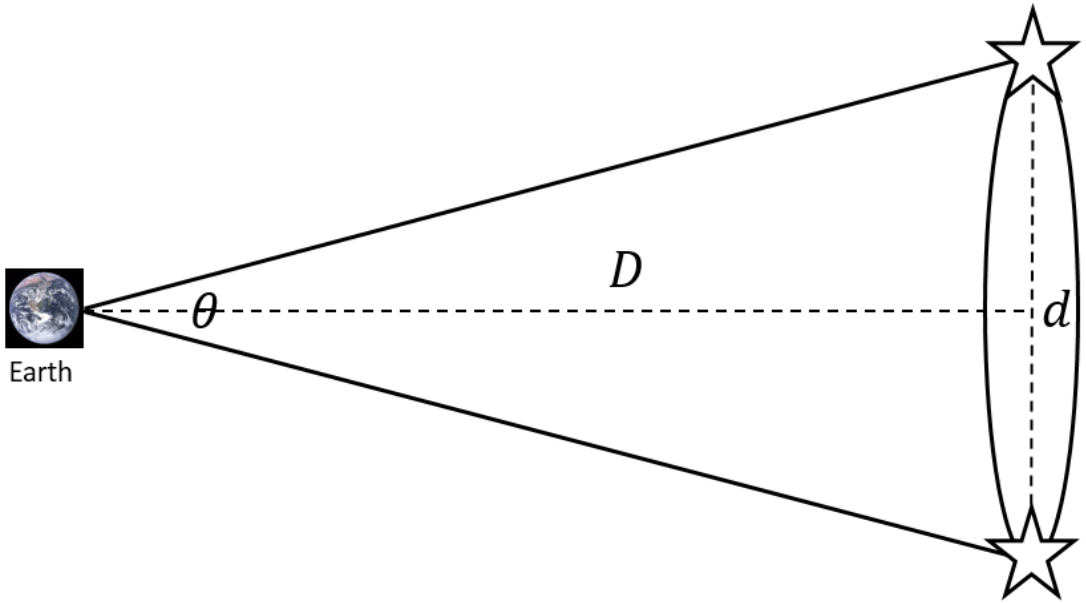
Small angles formula



$$\boldsymbol{\theta}_{arcseconds} = \frac{d}{206265 * D}$$

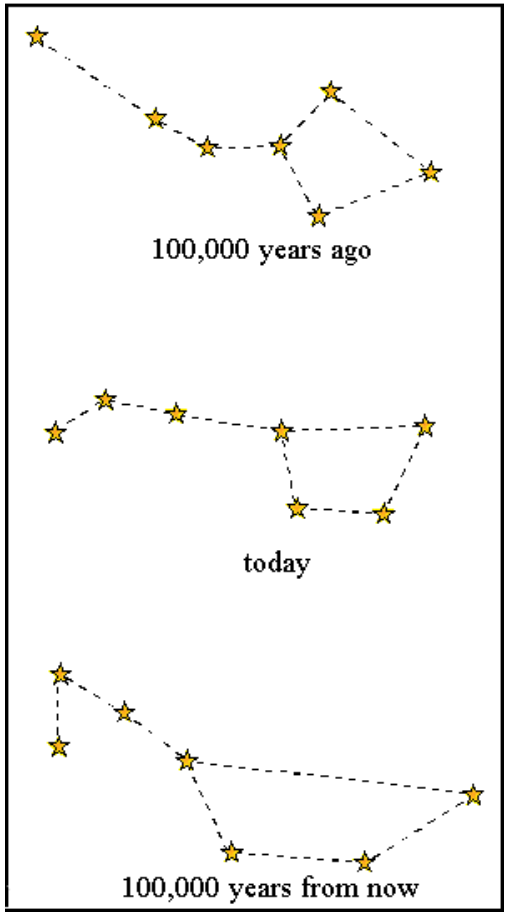
- $\boldsymbol{\theta}$ angular distance
- d diameter
- D distance

$$\theta_{arcseconds} = \frac{d}{206265 * D}$$

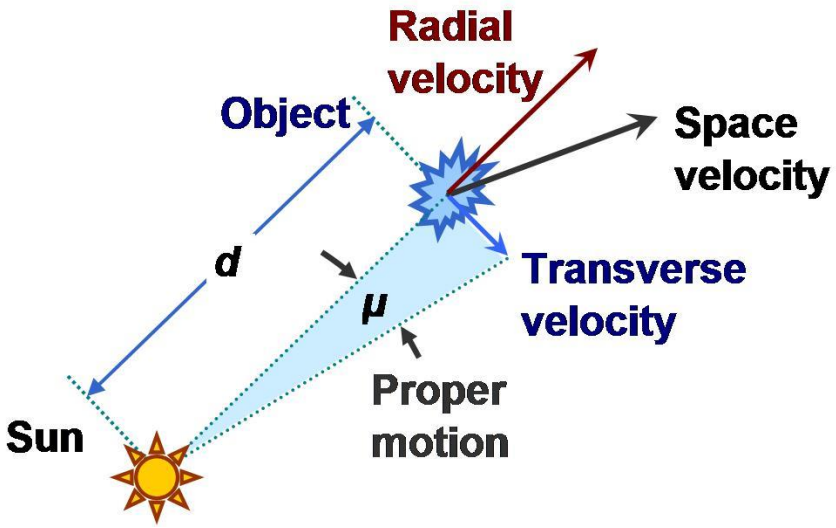
The motion of a star

The evidence for proving stars are moving

- Big Bang Theory
- The shape of the constellations are changing with time
- Red Shift



Transverse, Space(True) and Radial Velocities



$\boldsymbol{\mu} - Proper\ motion$
The angular distance from the earth traveled in one year

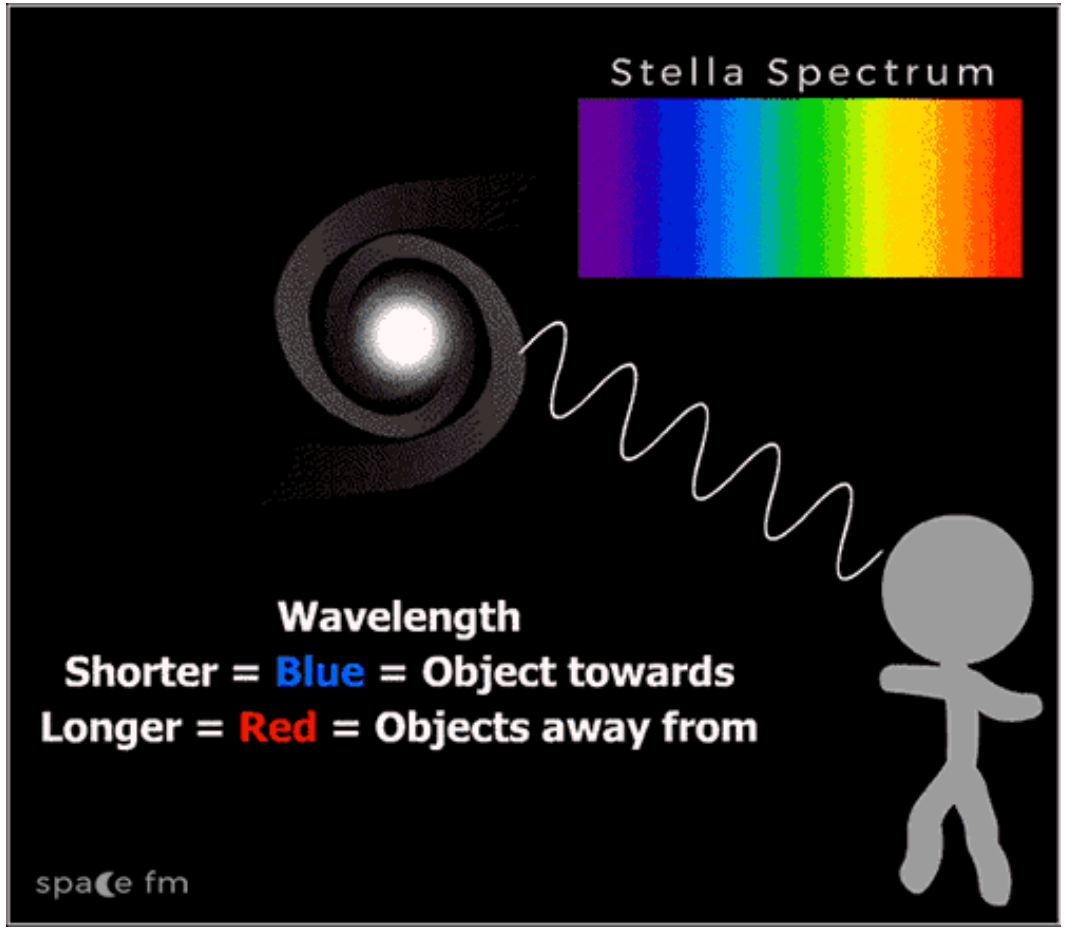
$$V_T = 2.74 * \boldsymbol{\mu} * d$$

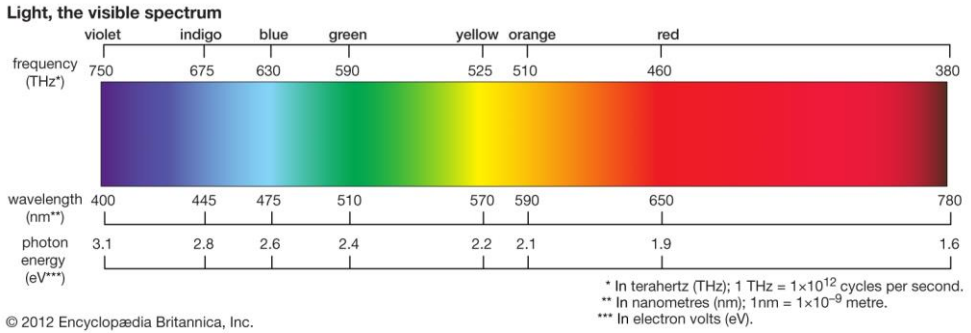
V_T - Transverse velocity
$\boldsymbol{\mu}$ - Proper motion of the star

$$V_T{}^2 + V_R{}^2 = V_S{}^2$$

V_T - Transverse velocity
V_R - Radial velocity
V_S - Space velocity

Red Shift





Due to the movement of the star the light rays from the star are shifted to the red region of the spectrum. This is called as **RED SHIFT**

If the star was moving towards earth then the lights rays are shifted to blue region. And this is called as BLUE SHIFT
(This is a rare incident)

Red Shift(Z) equations

$$\frac{V_R}{C} = \frac{\boldsymbol{\lambda} - \boldsymbol{\lambda_0}}{\boldsymbol{\lambda_0}}$$

V_R - Radial Velocity

C – Velocity of light (3 * 10^8 ms-1)

$\boldsymbol{\lambda}$ - Observational wavelength

$\boldsymbol{\lambda_0}$ -True wavelength

This equation is valid only for the cases where the velocity of the object(Star) is comparatively law with velocity of light
But in some cases (Mostly quasars) the velocity of the object is not negligible with speed of light
In those cases we have to use specified red shift equations

Relativistic Red Shift

As mentioned above when the velocity of the object is nearly equal to speed of light we have to use relativistic red shift equations which are a modified version of red shift equations

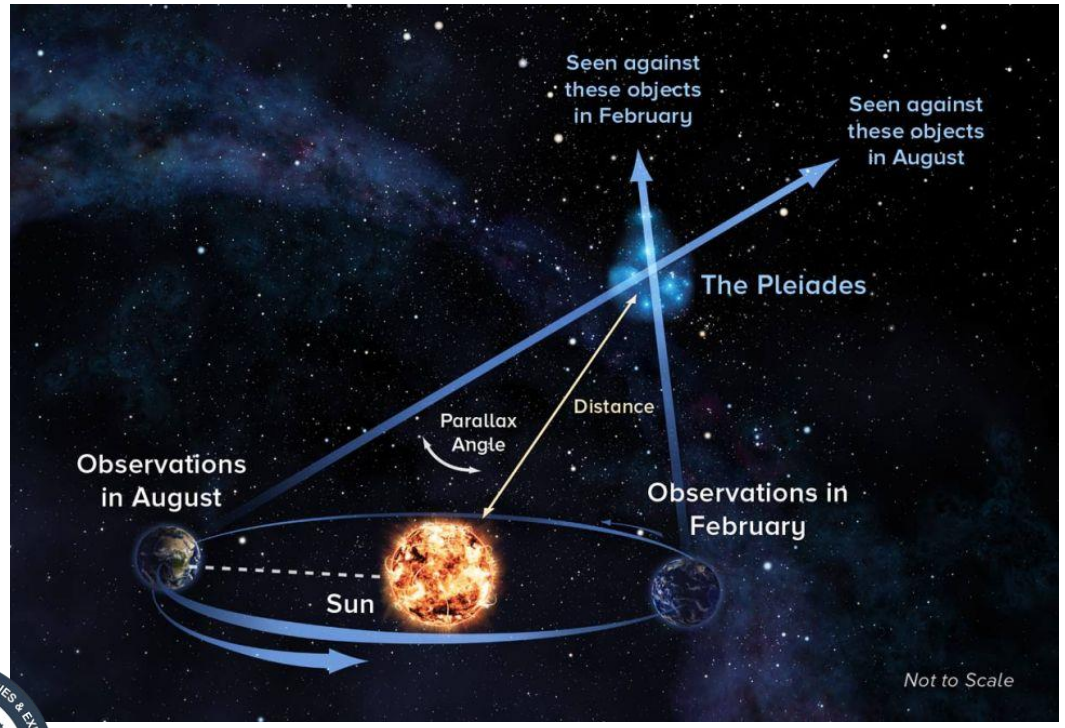
$$\lambda' = \lambda * \frac{\sqrt{1 + v/c}}{\sqrt{1 - v/c}}$$

V_R - Radial Velocity
C – Velocity of light (3 * 10^8)
$\boldsymbol{\lambda}$' - Observational wavelength
$\boldsymbol{\lambda}$ - True wavelength

Methods of measuring distances to the stars

- Parallax method
- Cepheids
- Supernovae
- Red Shift and Hubble law
- Tully Fisher method

Parallax Method



$$D = \frac{1}{P}$$

D – Distance(in Pc)
P – Parallax angle (in arcsec)

- Parallax angle s the **angle** between the Earth at one time of year, and the Earth six months later, as measured from a nearby star. Astronomers use this **angle** to find the distance from the Earth to that star.

- **Parallax** angles of less than 0.01 arcsec are very difficult to **measure** from Earth because of the effects of the Earth's atmosphere. This limits Earth based telescopes to **measuring** the **distances** to stars about 1/0.01 or 100 parsecs away

Hubble law

The velocities of the galaxies moving away from earth are proportional to their distance from earth.

$$V = H_0 * d$$

d – distance from earth (Unit MPc)

V – Radial Velocity of the galaxy (Unit kms^{-1})

H_0- Hubble constant

(Hubble constant changes with time. Present days H_0 is approximately taken as 70 km$s^{-1}MPc^{-1}$)

Finding the distance using hubble law and Red Shift

$$\frac{V_R}{C} = \frac{\boldsymbol{\lambda} - \boldsymbol{\lambda}_0}{\boldsymbol{\lambda}_0} \qquad \mathrm{V} = H_0 * d$$

- First using spectrum data you have to find the radial velocity of the object
- Next using Hubble equation can obtain the distance to the galaxy

$$H_0 * d = \left(\frac{\boldsymbol{\lambda} - \boldsymbol{\lambda}_0}{\boldsymbol{\lambda}_0}\right) * C$$

Tully Fisher method

- Tully Fisher relation(TFR) is the relationship between rotational velocity and luminosity of a spiral galaxy.
- Faster the galaxy rotates its luminosity is higher
- We can measure rotational velocity using red shift
- When an object is rotating one part is coming towards us and the other part is going away from us
- So One side shows a red shift while the other side shows a blue shift
- Using this we can find the rotational velocity and using TFR Luminosity
- Once we find the luminosity using stellar physics we can find the distance

Cepheids variables

- Cepheids are a type of variable stars
- That pulsates radially producing changes in brightness with a well-defined stable period and amplitude.
- There is a relationship between period and Absolute magnitude of a Cepheid

$$\mathbf{M = -1.35 - 2.76 * log_{10} P}$$

M – Absolute magnitude

P - Period

- Using the relationship between absolute and apparent magnitude we can find the distance to the star

$$\mathbf{m - M = 5 \log(\frac{d}{10})}$$