Course of General Astronomy

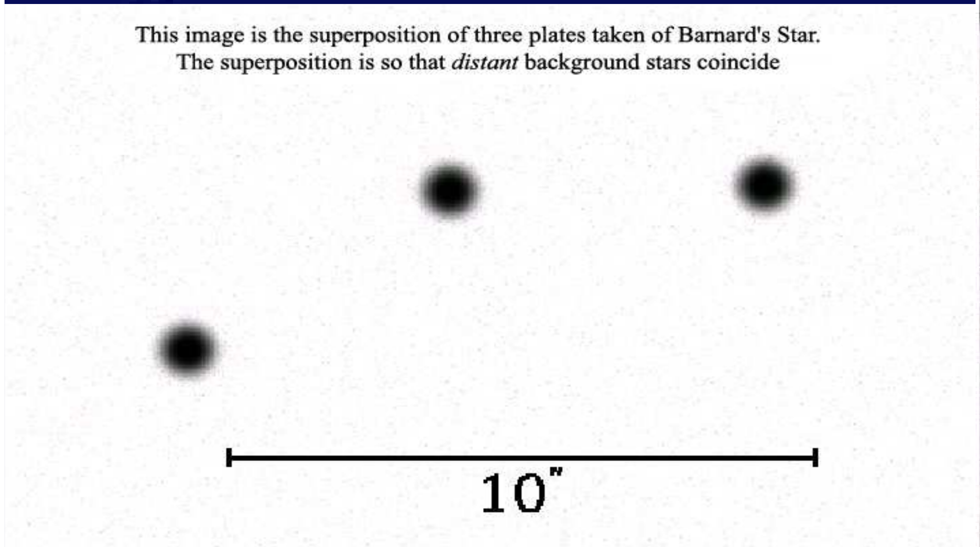
Gulu University

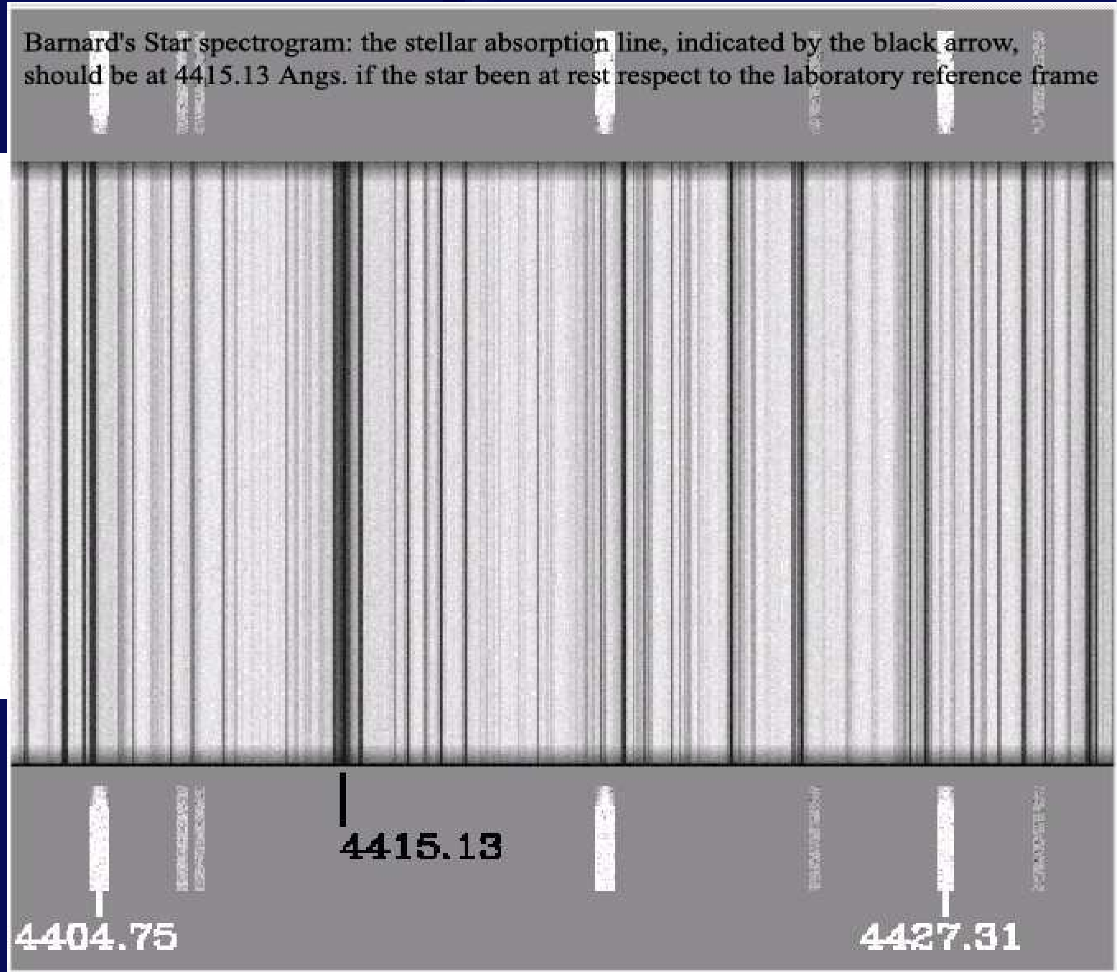
Naples FEDERICO II University

3

Distance, Velocity & the Case of Barnard's Star

Experiment n. 2: materials (*2 images*)





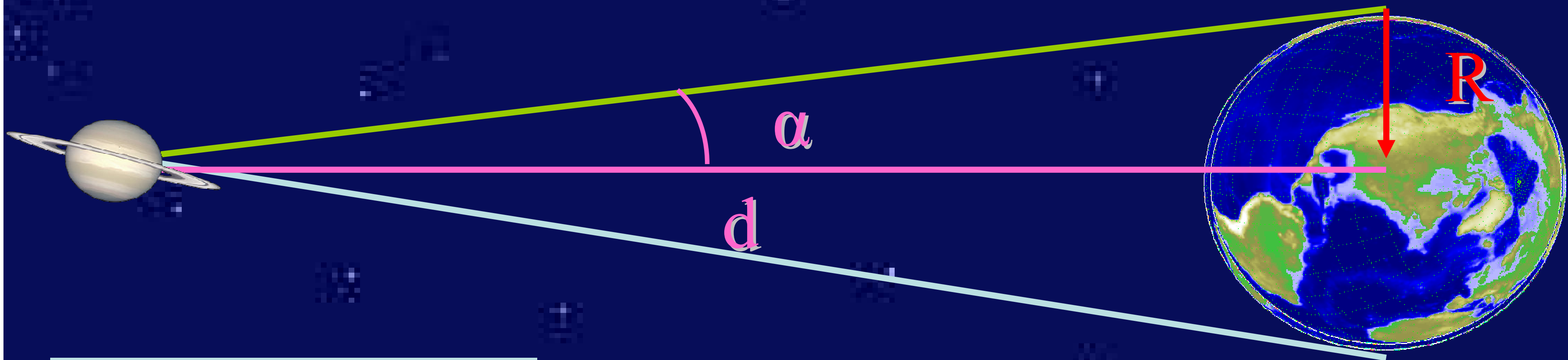
The photograph is a superposition of three plates taken of Barnard's Star at roughly six-month intervals *(the superposition is made so that the very far background stars coincide in all three plates)*.

On the spectrogram they are reported the wavelengths *(in Å=10^{-10} m)* of two comparison lines and the absorption line wavelength, at rest, of a recognized chemical element present on the Barnard's Star spectrum.

Determine the current distance of the star, its total velocity respect to the Sun, the year of its minimum distance from the Sun and the minimum distance.

Searching for a base …

for solar system objects … Earth radius



$$d = \frac{1}{\alpha''}\left(206265R\right)$$

α'' → diurnal parallax

Where can we arrive using the Earth radius?

$\alpha = 1'' \rightarrow d = 1.3\times10^{9}$ Km

The closest star (Proxima Centauri) $\rightarrow d = 4.04\times10^{13}$ Km !!

To go for stars …

we need a new (longer) base !!!

The largest base …

b = radius of terrestrial orbit = 1.49×10^{8}km = 1 A.U.

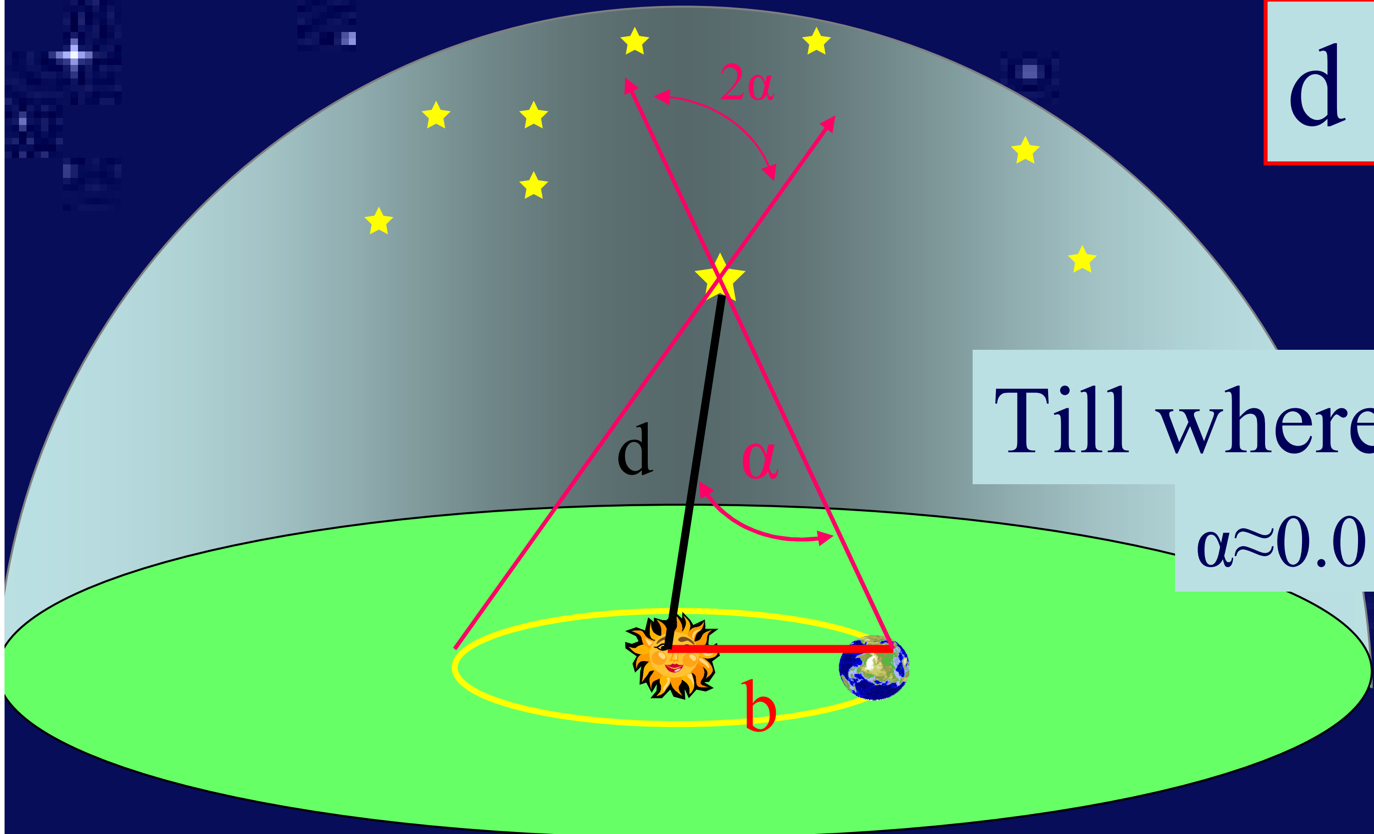
α" ⟶ parallax (annual)

$$d = \frac{1}{\alpha''}(206265b)$$

1pc=206265 AU=3.08×10^{13}km

$\boxed{\text{d } \textit{(in pc)} = 1/\alpha''}$

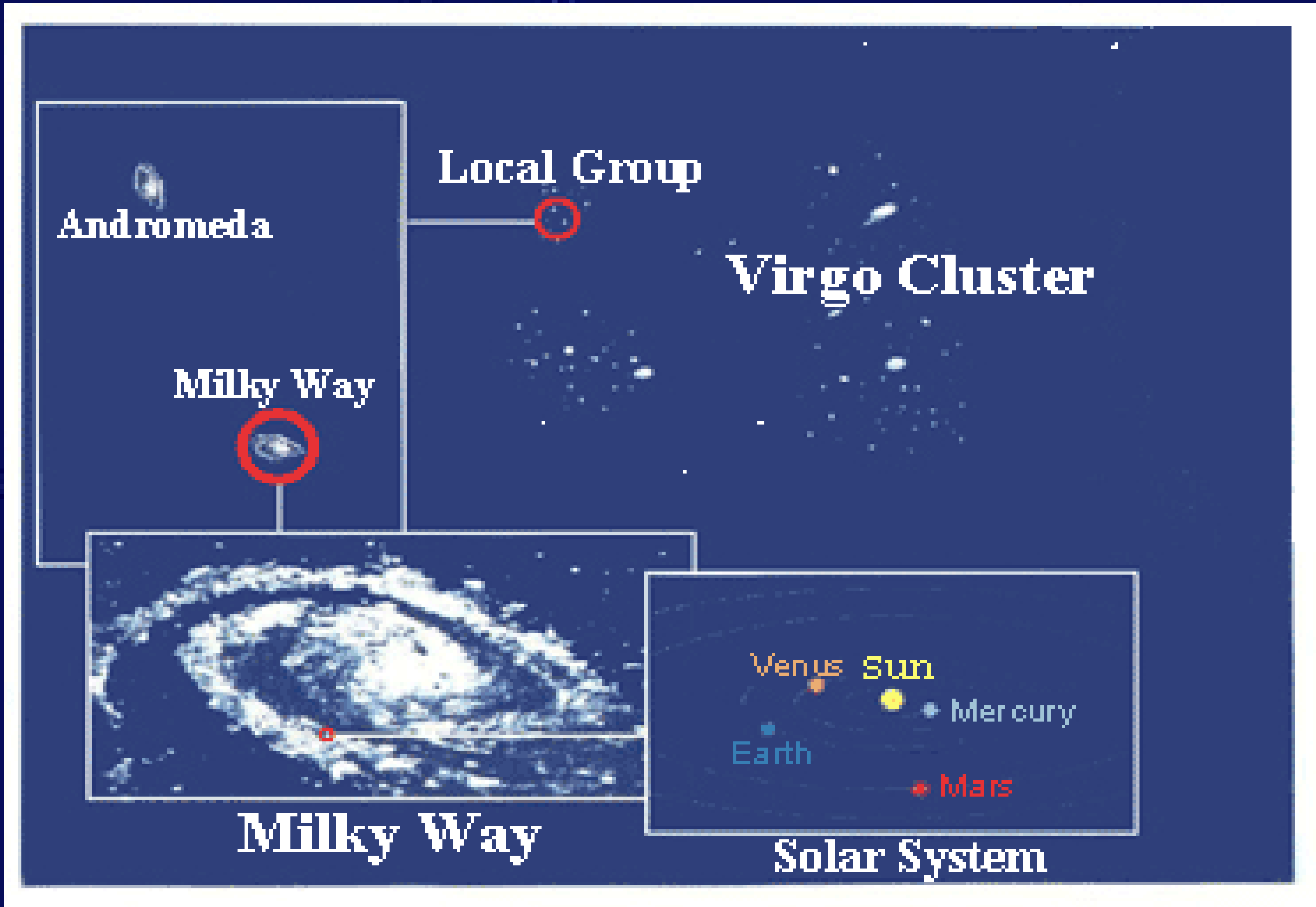
1pc=3.26 l.y.



Till where can we go ?

α≈0.01"⇒100 *pc*=326 l.y.

Where have we go ??



(FROM PREVIOUS LECTURE)

Light ?

….. Massless particles called **PHOTONS**

(Their speed is **c=299 792 458** m̃s, in the vacuum)

They act as :

- **Particles** **(interacting with matter)**
- **Waves** **(propagating)**

Waves ?

(From previous Lecture)

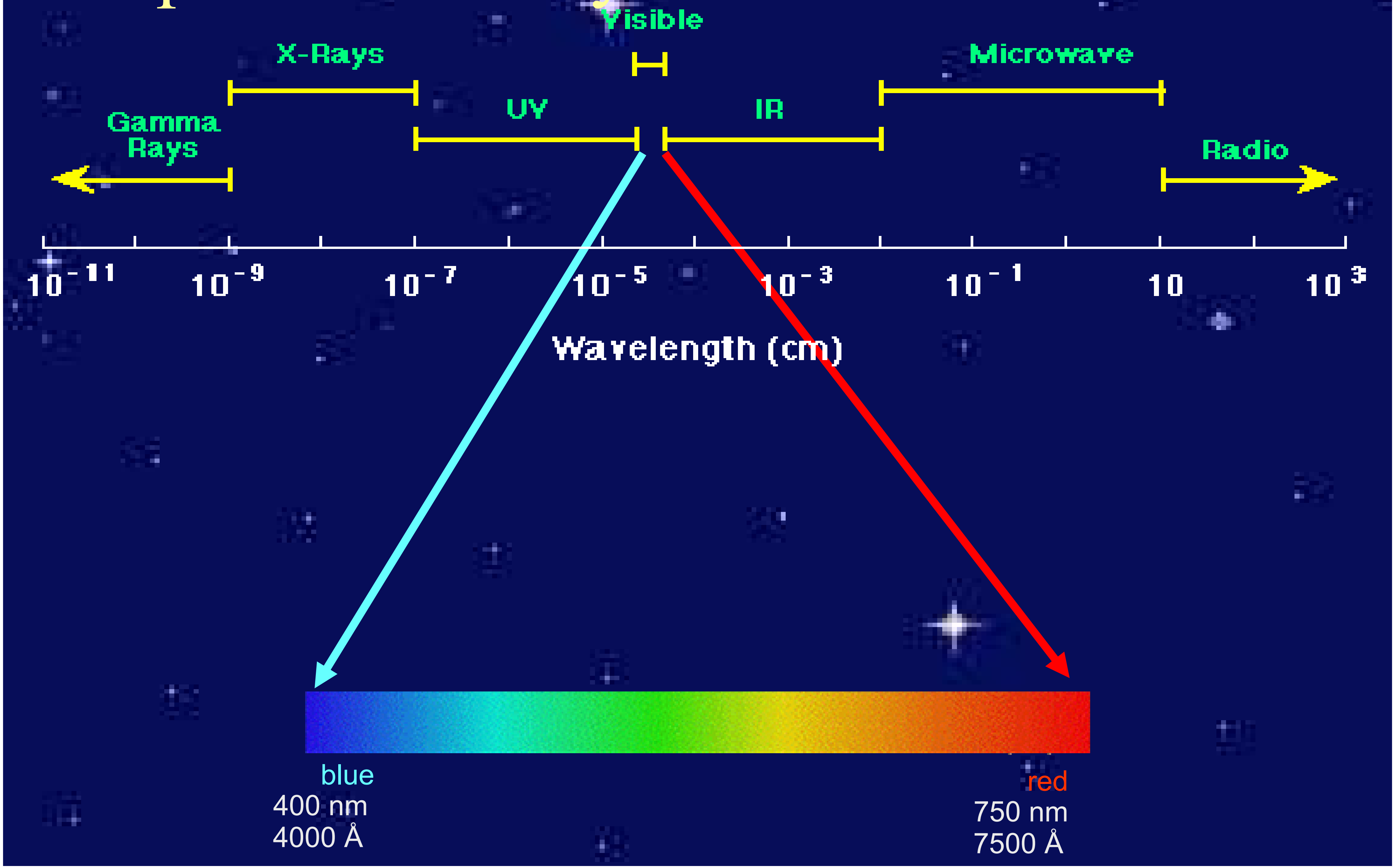
- Wavelength **λ**
- Frequency **$\nu=c/\lambda$**

Photon energy:

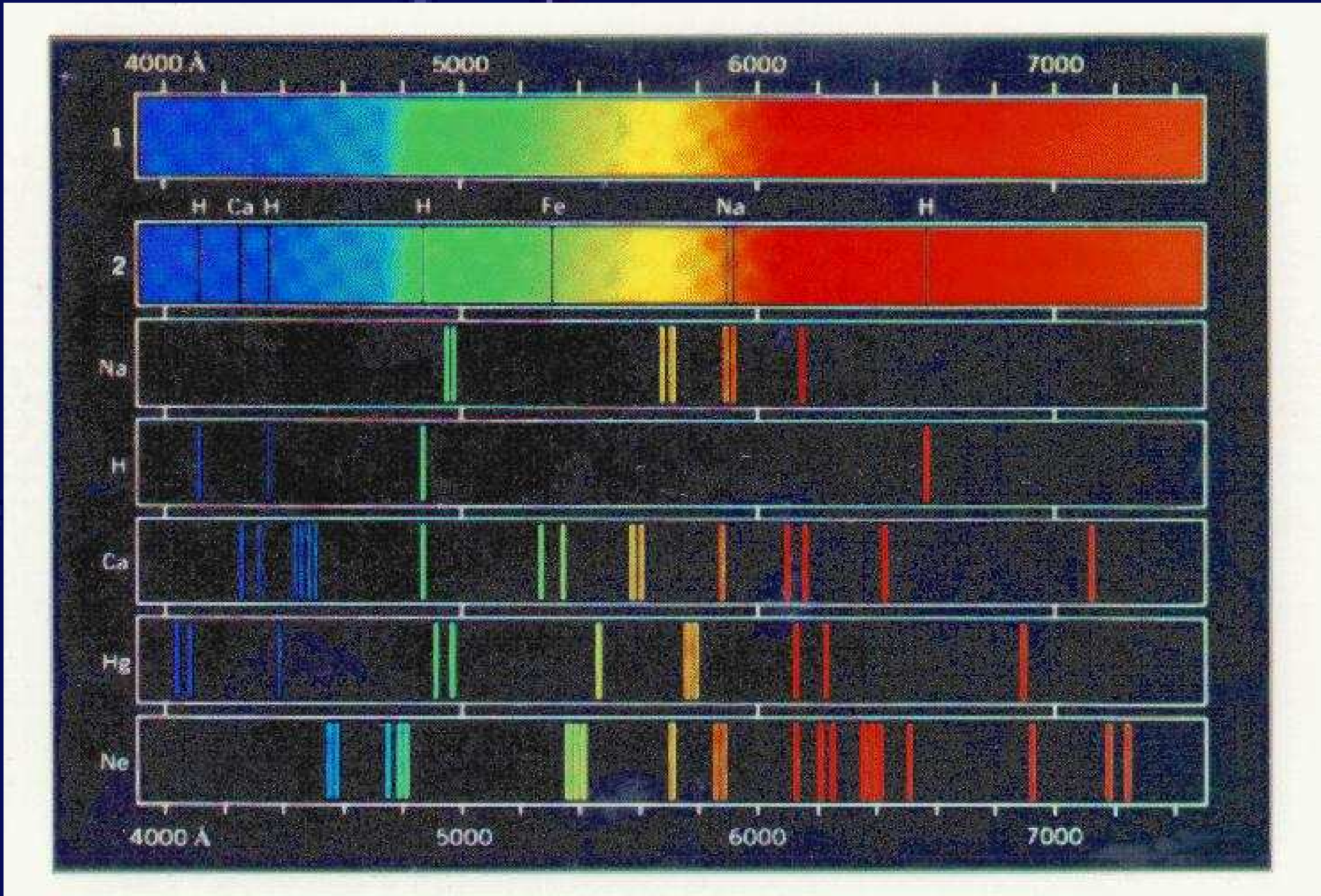
$$h\nu=hc/\lambda$$

(h=Planck's constant=6.626×10^{-34} joule per sec)

The photons family: (From previous Lecture)

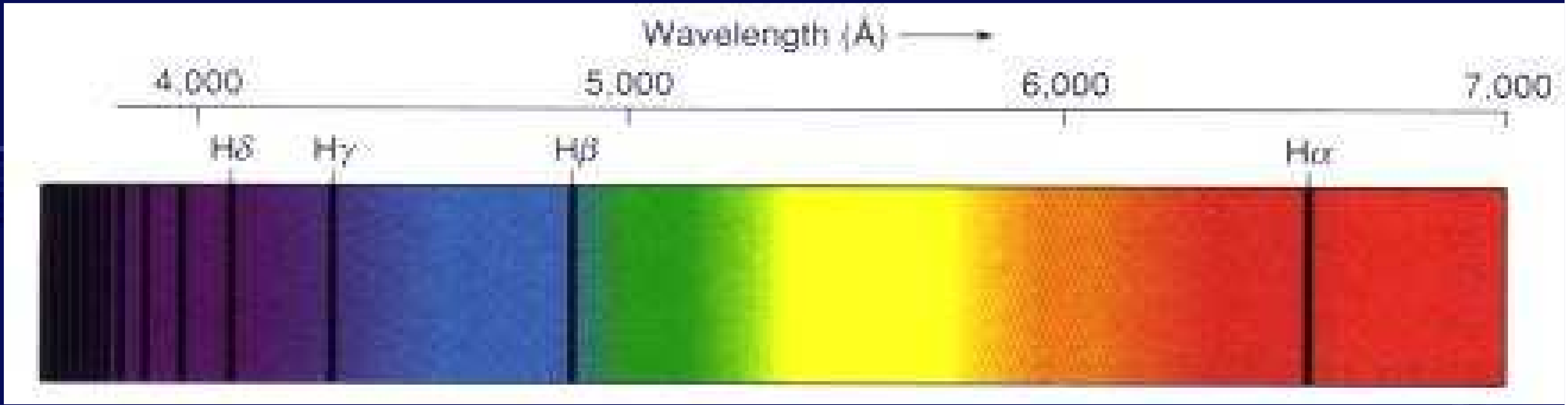


Spectra:

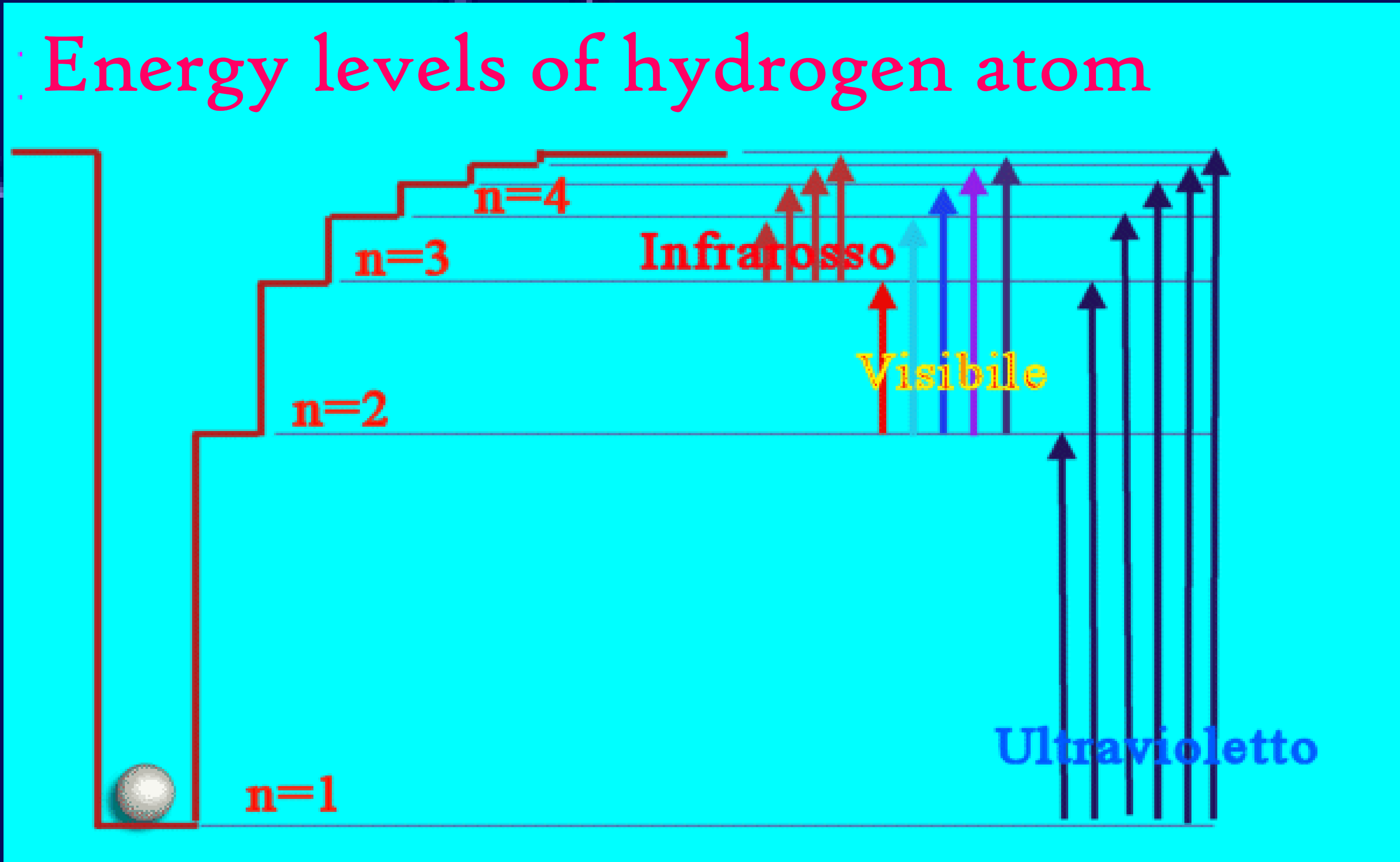


4000 Å
5000
6000
7000
1
H
Ca
H
H
Fe
Na
H
2
Na
H
Ca
Hg
Ne
4000 Å
5000
6000
7000

Stellar Spectra:

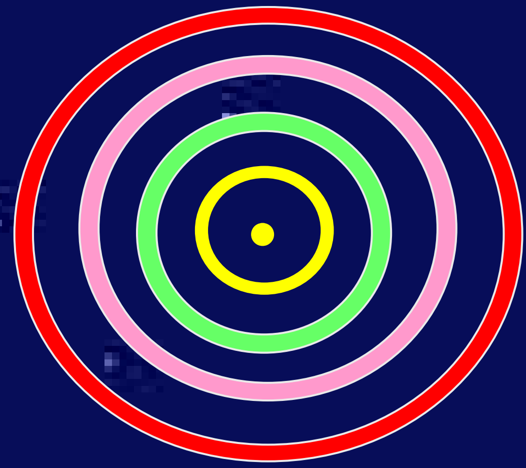


Why spectral lines ?

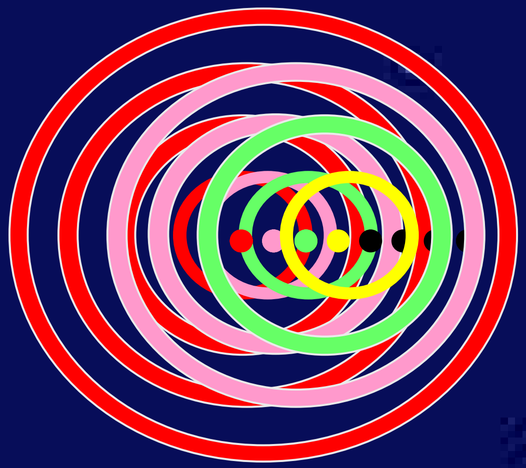


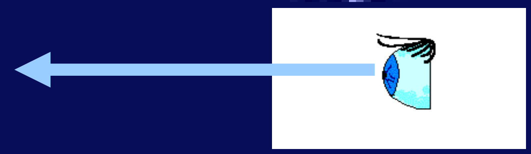
Doppler Effect:

standing source



source in motion





We see lengthened wavelengths (shifted toward red side)

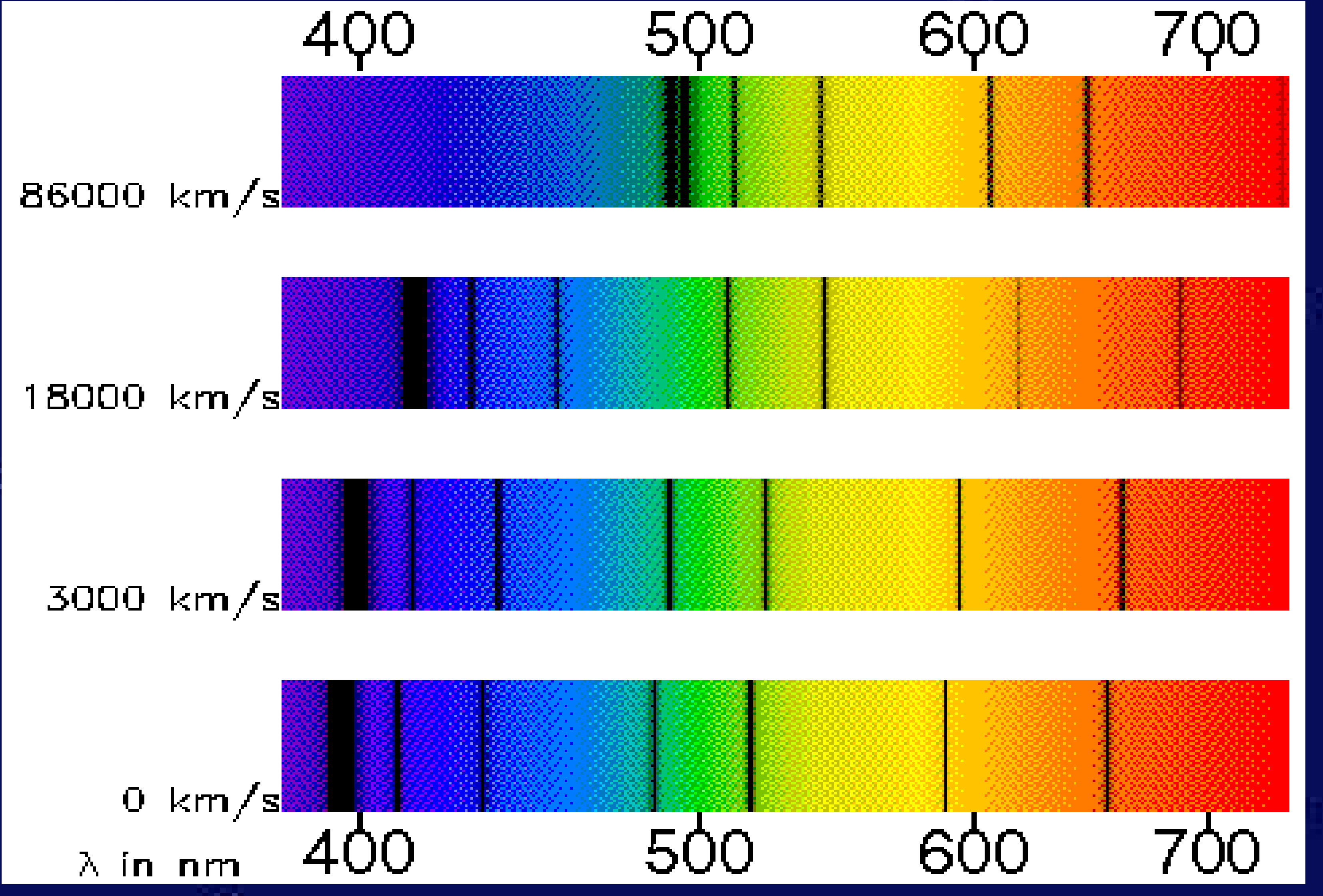
redshift

We see shortened wavelengths (shifted toward blue side)

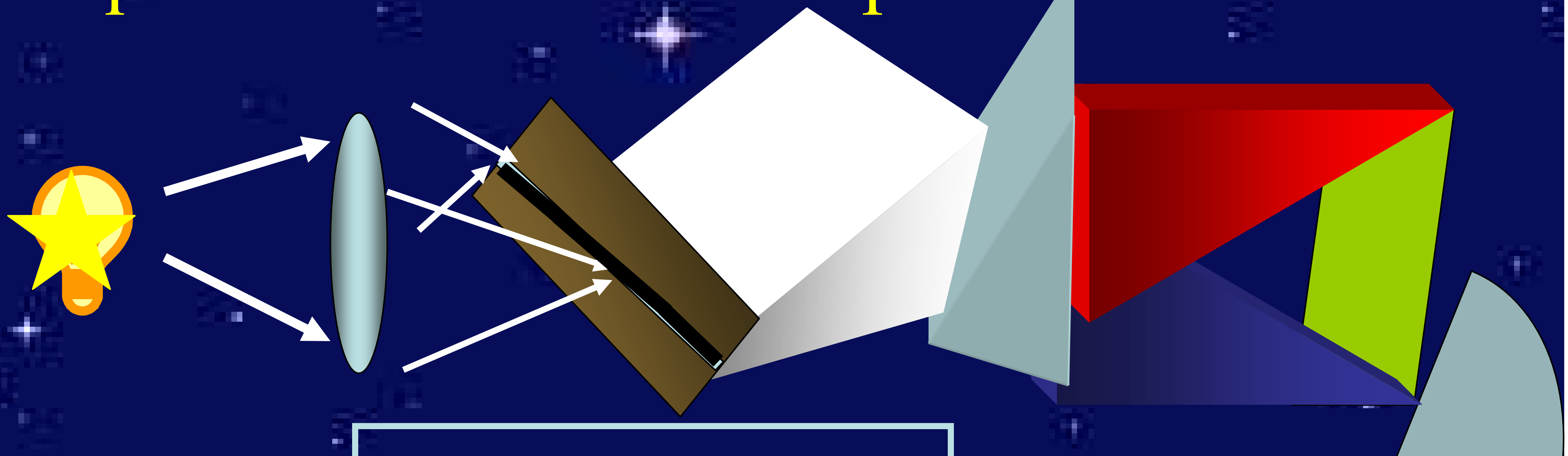
blushift

$$\Delta\lambda = \lambda v/c$$

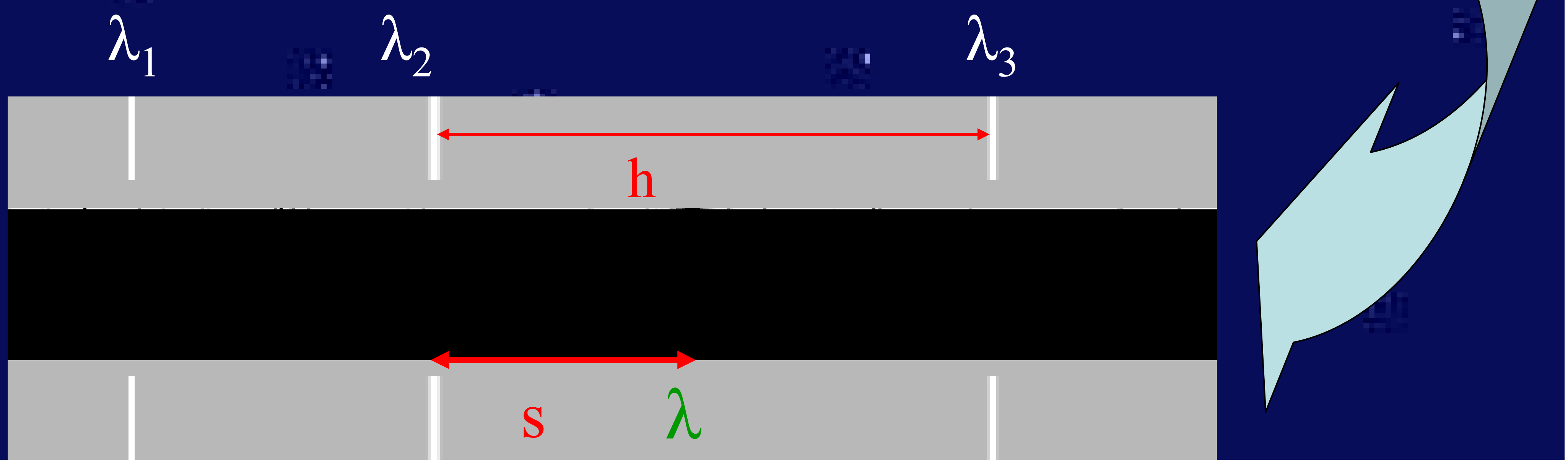
As is appearing … the spectrum of moving object?



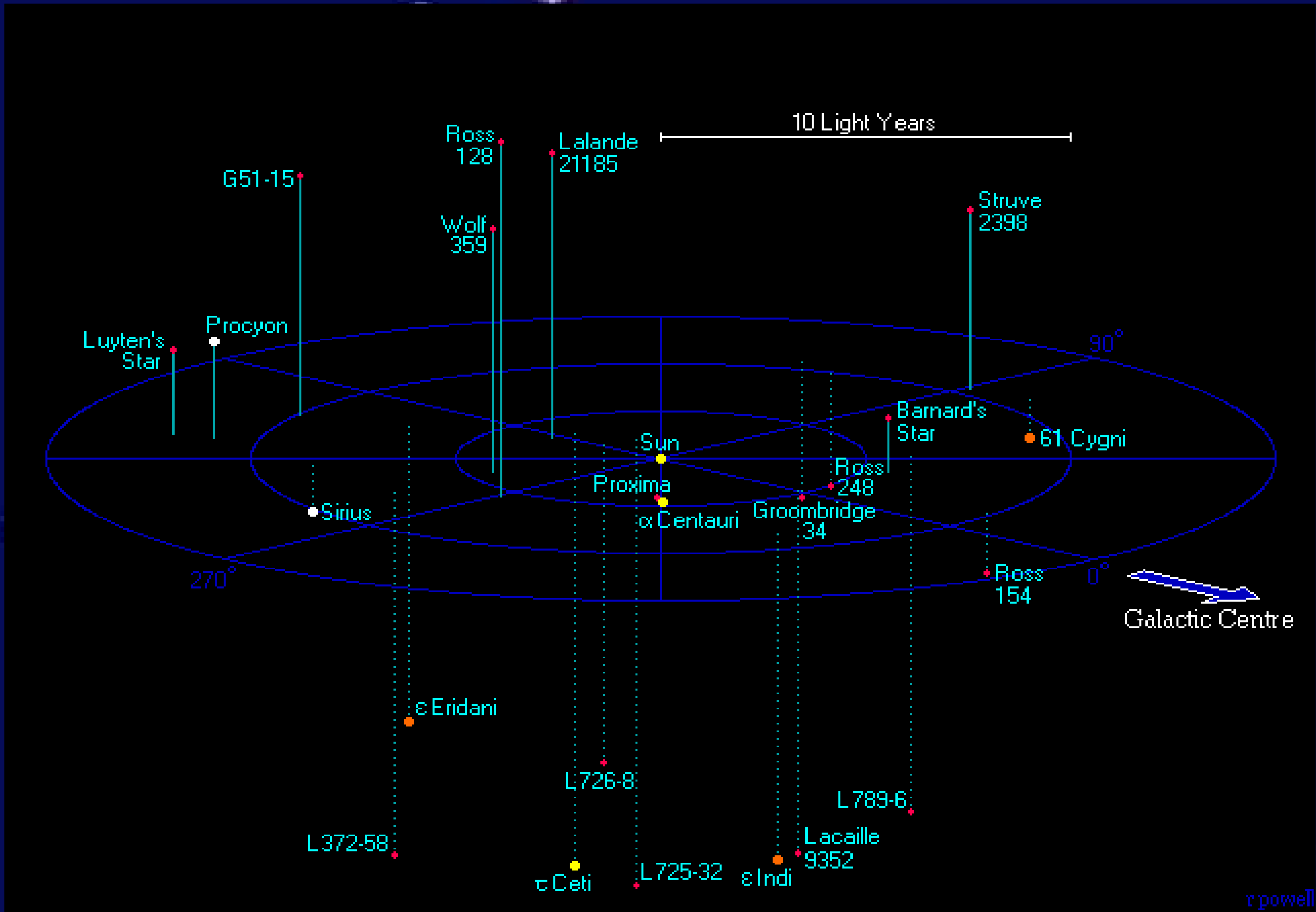
Acquire and calibrate the spectrum:



$$\lambda=\lambda_2+(\lambda_3-\lambda_2)s/h$$

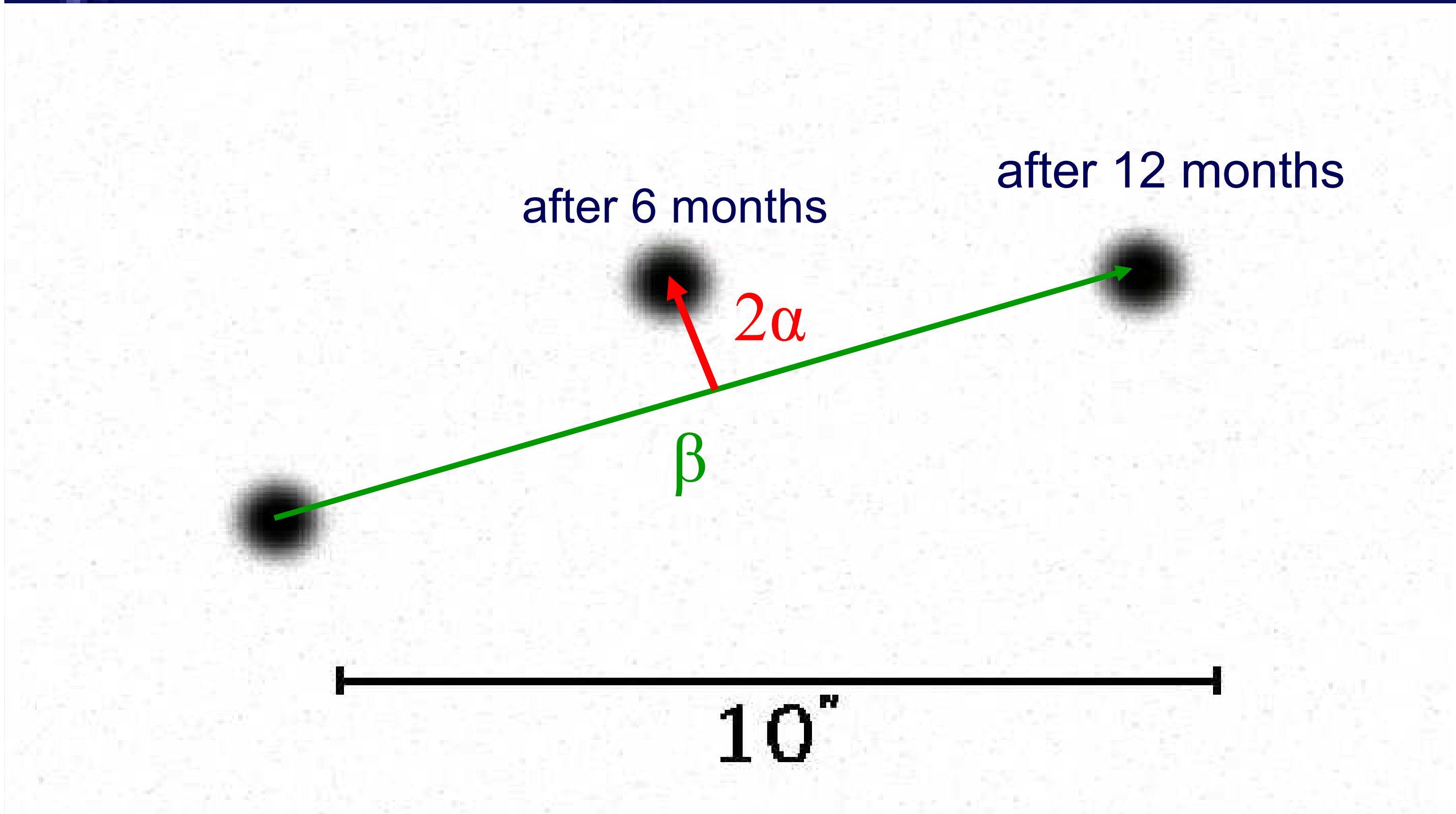


Stars at 15 l.y. from us



Three images of B.S. at 6 month interval

(superposition is made so that the *very far* background stars coincide)



α parallax

$d = 1/\alpha$ =

distance in pc

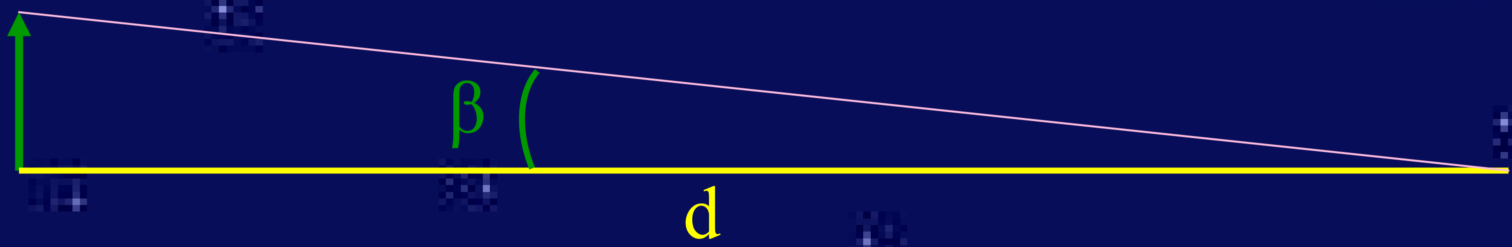
β proper motion

in *''/year tangent. velocity*

in pc/year

in Km/year

in Km/sec



Spectrogram of Barnard's Star

Comparison spectrum

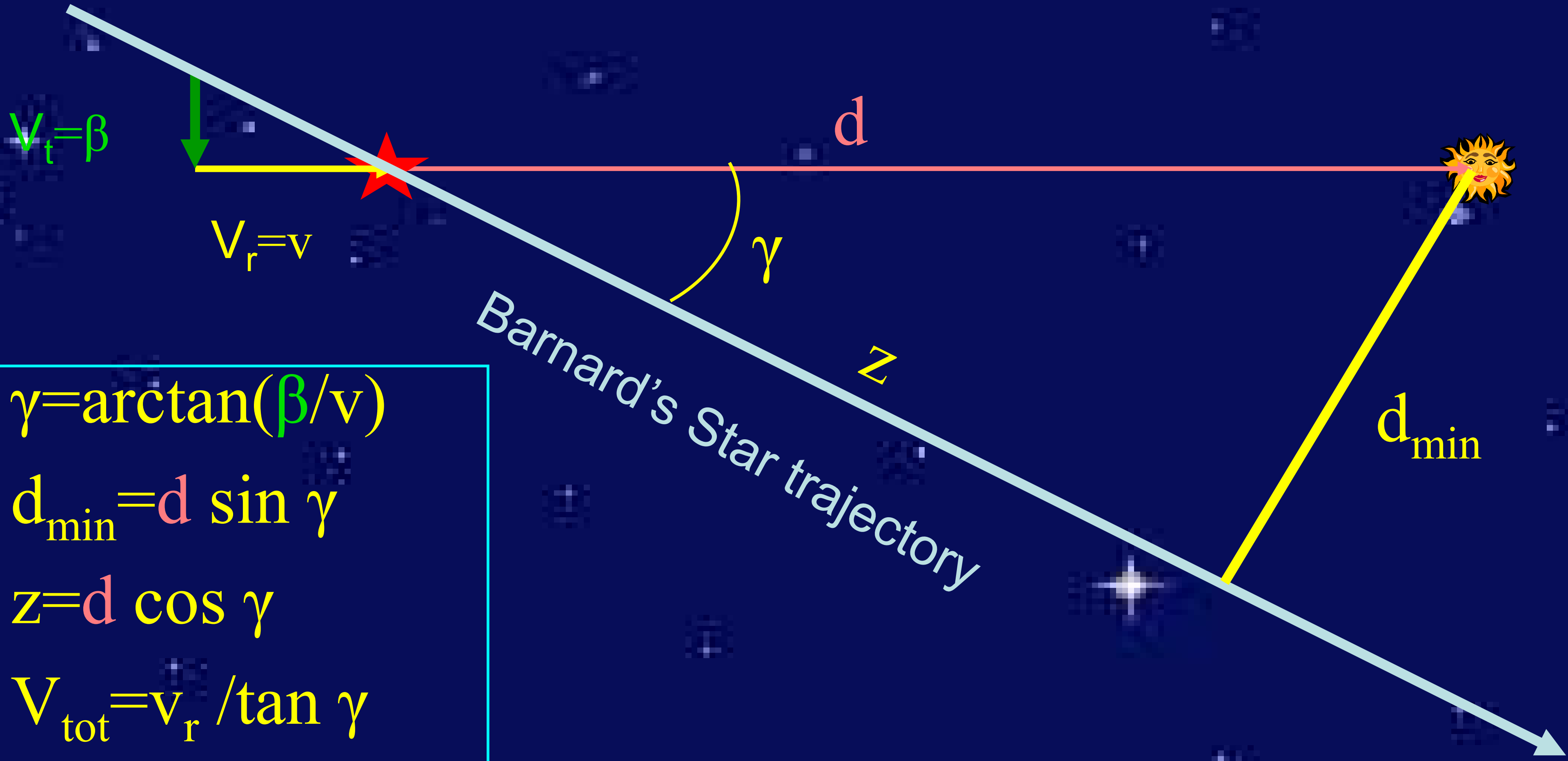
Barnard's Star spectrum

$\lambda = 4404.75 + (22.56) \times s/h$

$v = c(\lambda - 4415.13) / 4415.13$

Comparison spectrum

Geometry of Barnard's Star motion



$\gamma = \arctan(\beta / v)$

$d_{min} = d \sin \gamma$

$z = d \cos \gamma$

$V_{tot} = v_r / \tan \gamma$

$\Delta t = z / V_{tot}$

Steps

1. Distance to Barnard's Star
2. Proper motion of B.S.
3. Radial velocity of B.S.
4. Total velocity of B.S.
5. Minimum distance of B.S.
6. Year of B.S. minimum distance
7. Explain *(shortly)* the used methods