Intro activity

- Spread out the contents of the envelope on your desk
- First, order them from youngest to oldest
- Second, order from smallest to largest
- Third, order from nearest to farthest

Star finder assignment

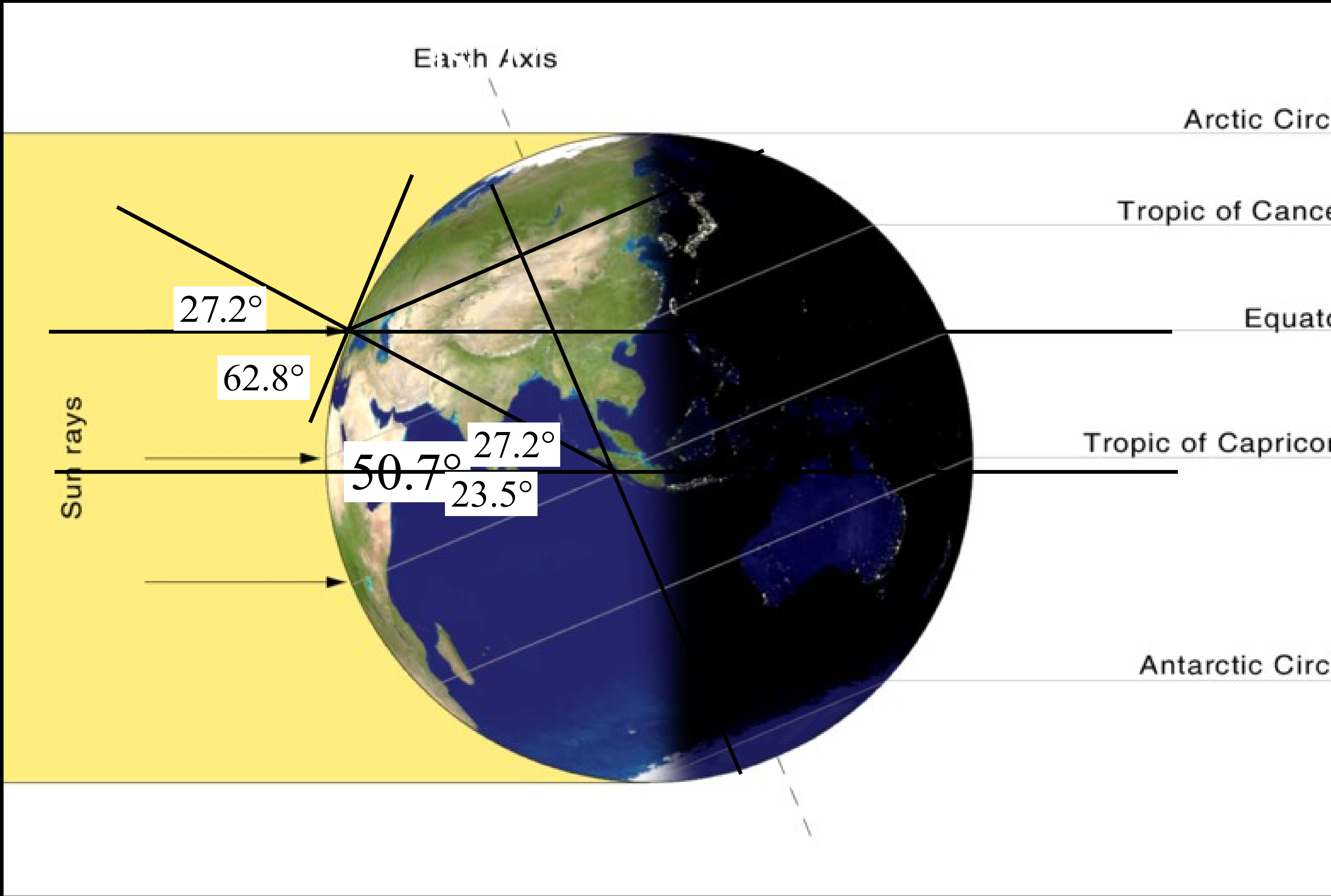
- Find the constellations you would find at 9pm tonight:
- Over the Northern horizon
- Over the East horizon
- Straight over head

- Tonight, go outside and:
- Find the moon: what constellation is it in?
- Find Mars: it should be in Scorpius

Option D

No, we aren’t going to talk about

[Star Wars]



Earth Axis
Arctic Circ
Tropic of Cance
Equato
Tropic of Capricor
Antarctic Circ
Sun rays
27.2°
62.8°
27.2°
50.7°
23.5°


ARCTIC OCEAN
ARCTIC OCEAN
NORTH PACIFIC OCEAN
NORTH ATLANTIC OCEAN
NORTH PACIFIC OCEAN
INDIAN OCEAN
SOUTH PACIFIC OCEAN
SOUTH ATLANTIC OCEAN
SOUTHERN OCEAN
ANTARCTICA

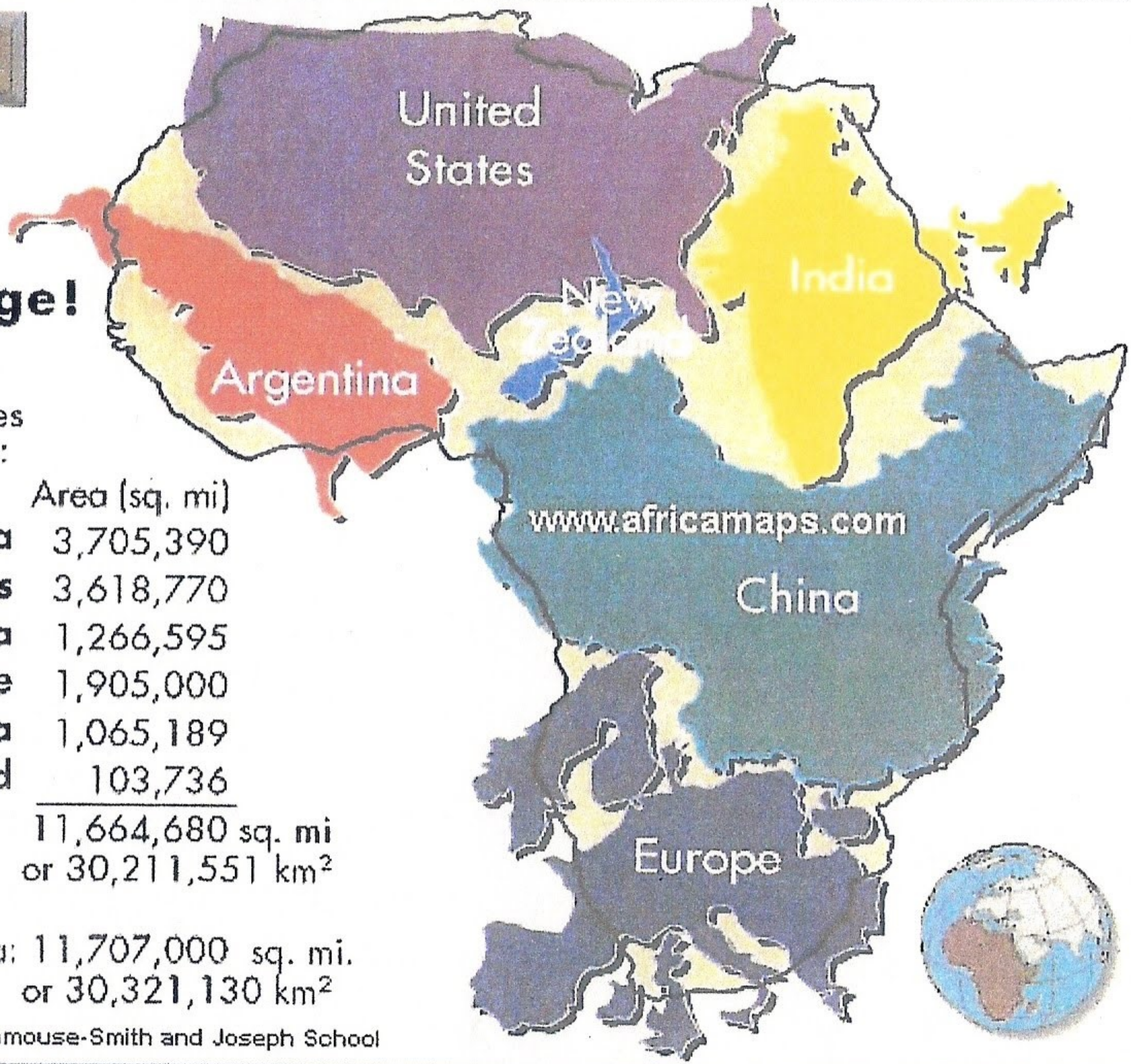
To the next map...

Africa is Huge!

The following countries could fit within Africa:

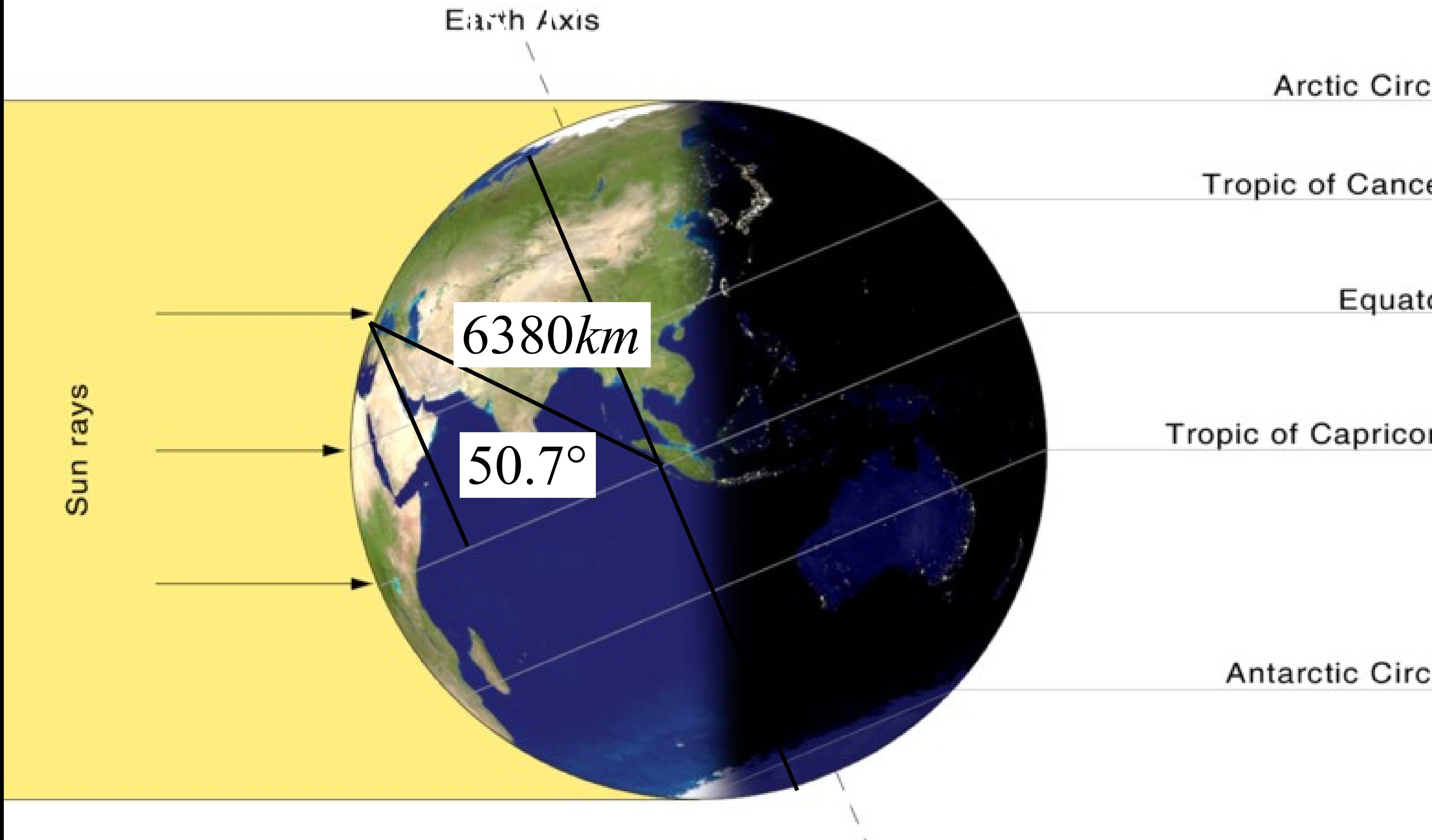
	Area (sq. mi)
China	3,705,390
United States	3,618,770
India	1,266,595
Europe	1,905,000
Argentina	1,065,189
New Zealand	103,736
	11,664,680 sq. mi or 30,211,551 km²

Africa's area: 11,707,000 sq. mi. or 30,321,130 km²



Earth's Rotation

- Given r = 6380 km How fast are people on the equator moving? How about Kamloopsians?
- v=d/t
- =circumference/24 hours
- =(40,000 km)/24 hours
- =464 m/s
- That's Mach 1.4!
- v(K)=298 m/s
- What if the Earth stopped spinning?



$$\cos\theta = \frac{A}{H}$$

$$A = H\cos\theta$$

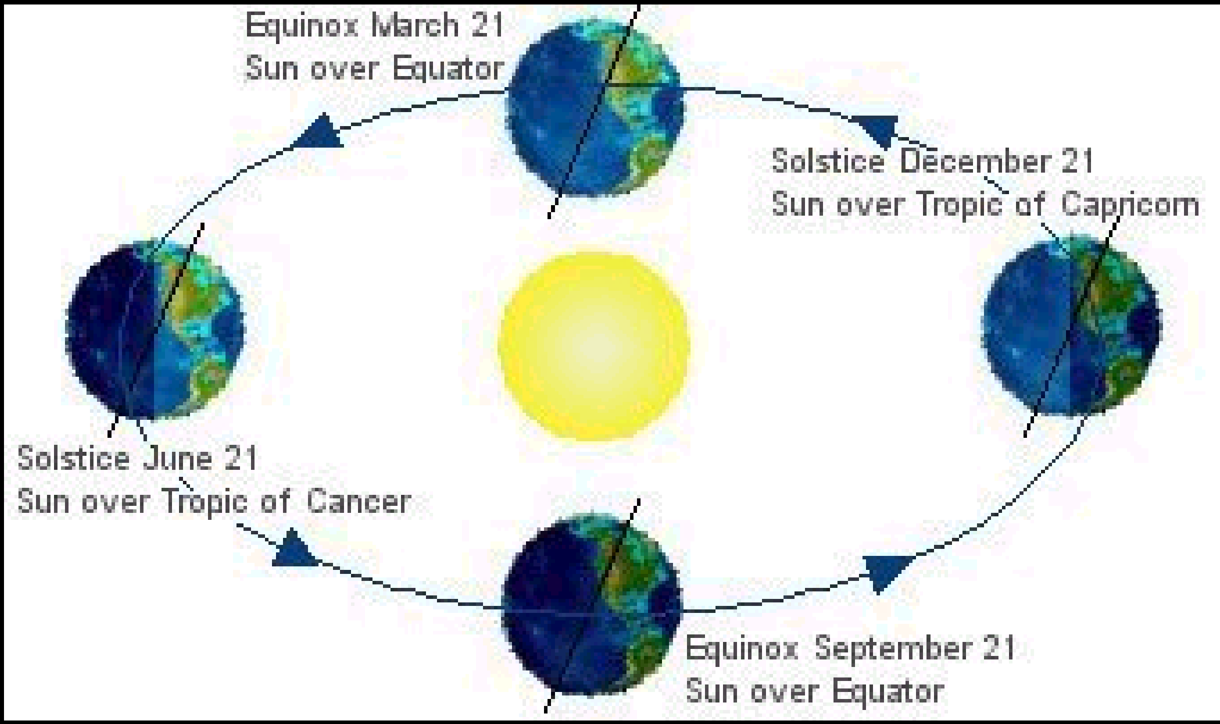
$$A_H = A\cos\theta$$

$$= 6380\cos 50.7$$

$$= 4041km$$

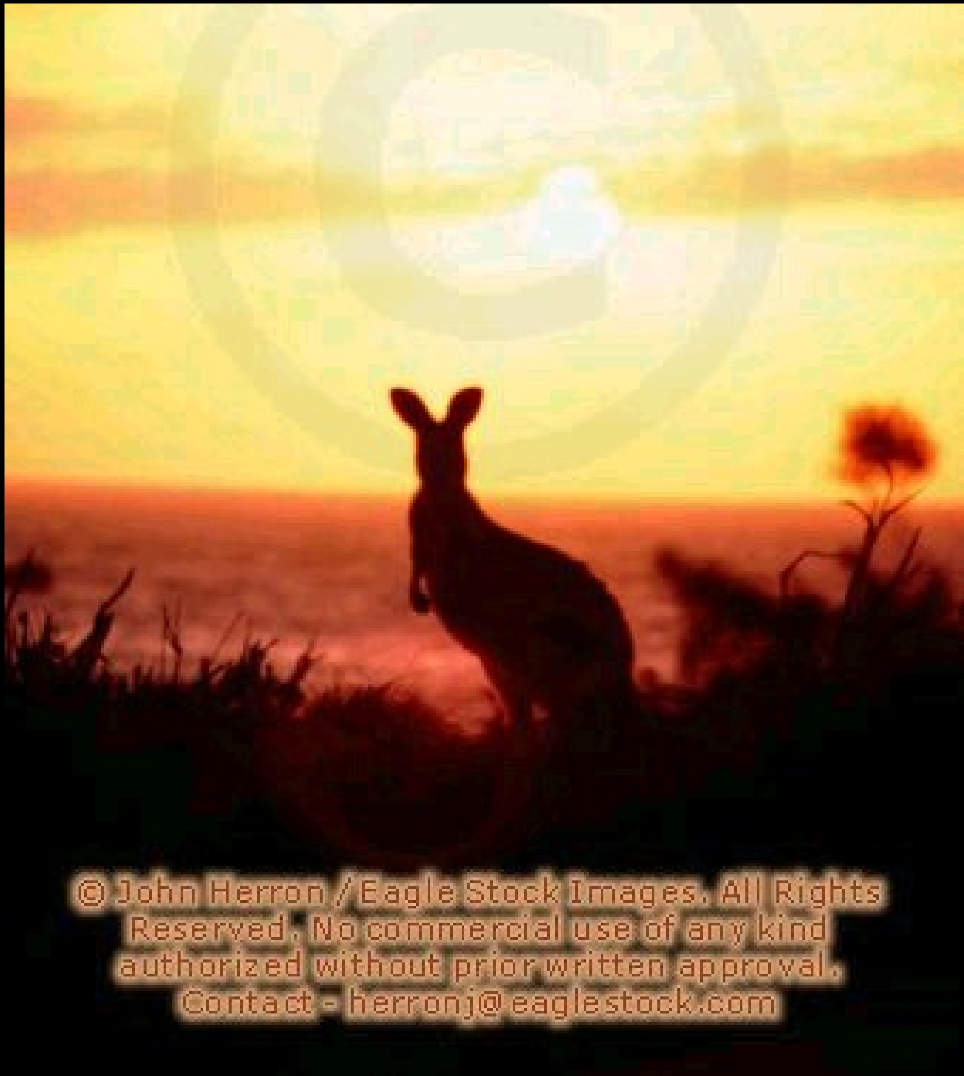
Why do we get seasons?

- The Earth's axis is inclined at 23.5º
- The Earth acts like a top and keeps the poles pointing in the same direction



Why is it winter in December?

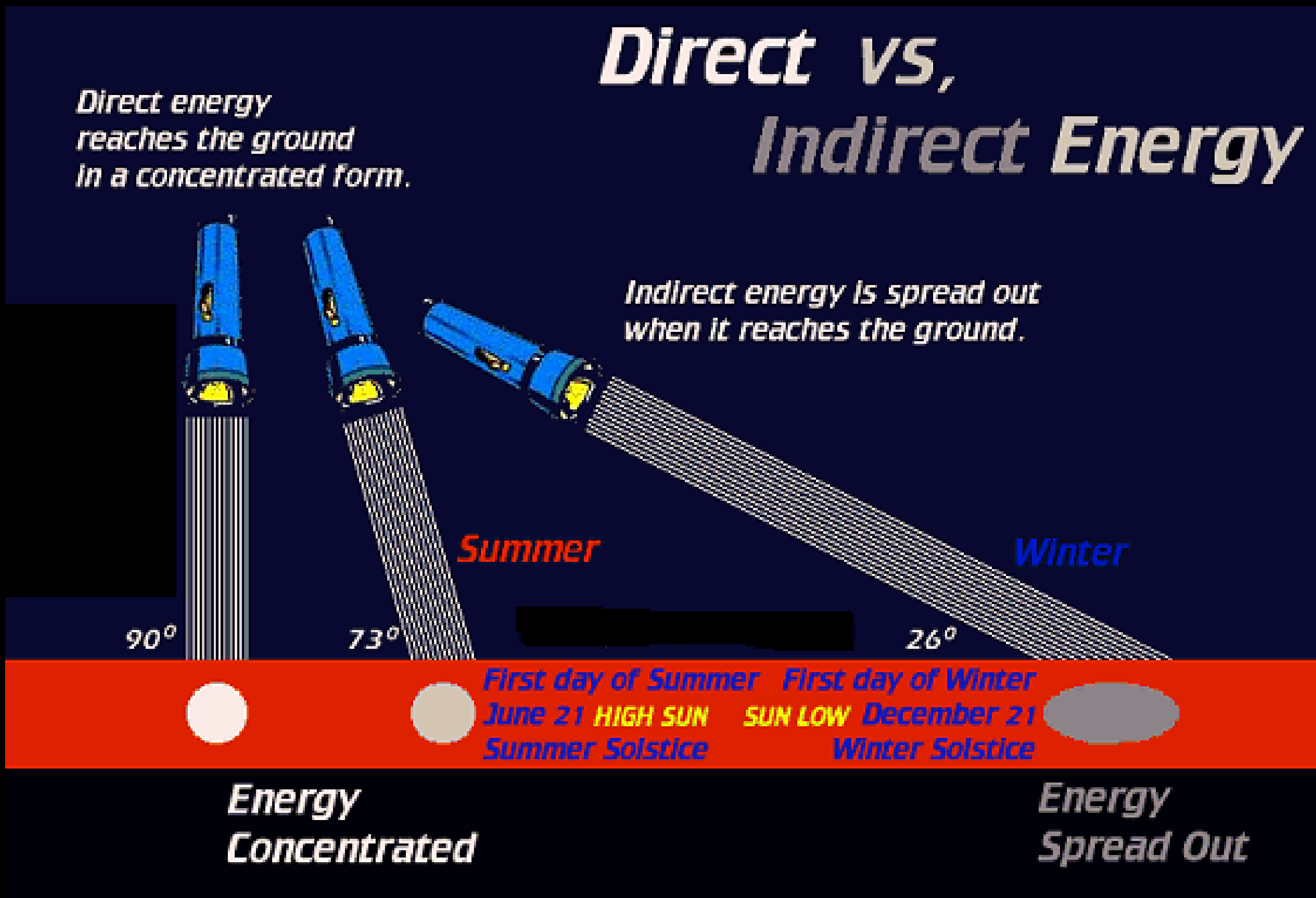
- The Northern hemisphere is pointing away from the sun: less direct sun, fewer daylight hours
- It's summer in Australia in Dec since the Southern hemisphere is facing the sun!



Midnight Sun?

- North of the Arctic circle, we get 24h of daylight on the Summer Solstice
- The Arctic circle is 23.5º from the North Pole, so 66.5º N lat

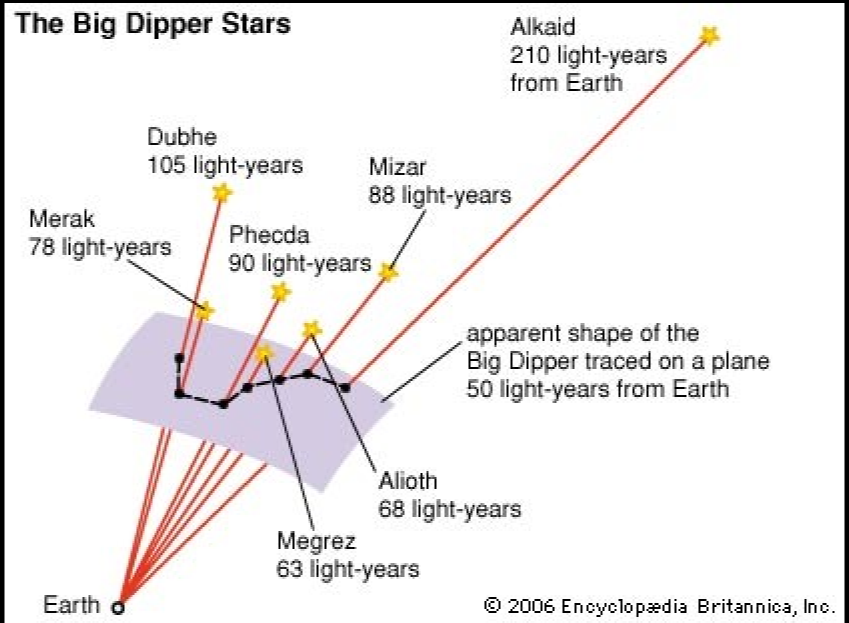
Winter Sun vs. Summer Sun




HÆMISPHÆRI
VM BOREALE
HÆMISPHÆRIO
UM STELLAT
CVM SUBIECTO
TERRESTRI.
Prostant Amstelaedami apud
PETRUM SCHENK et
GERARDUM VALK.
Cepheus
Ursa minor
GEMINI
Canis minor

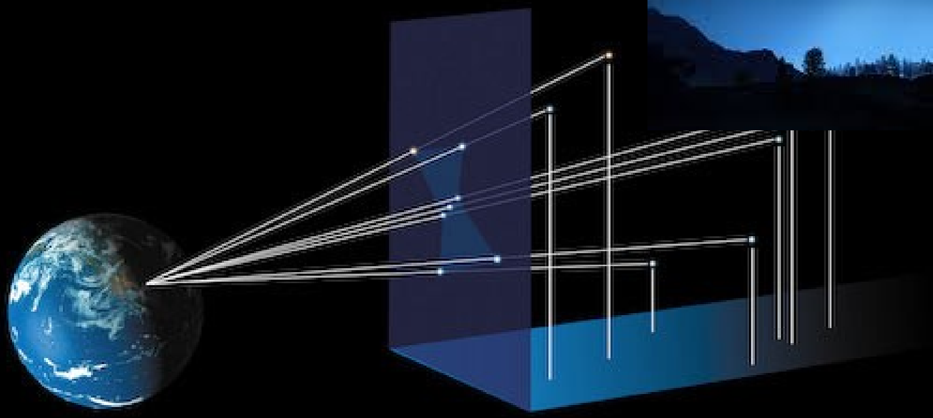
Constellations

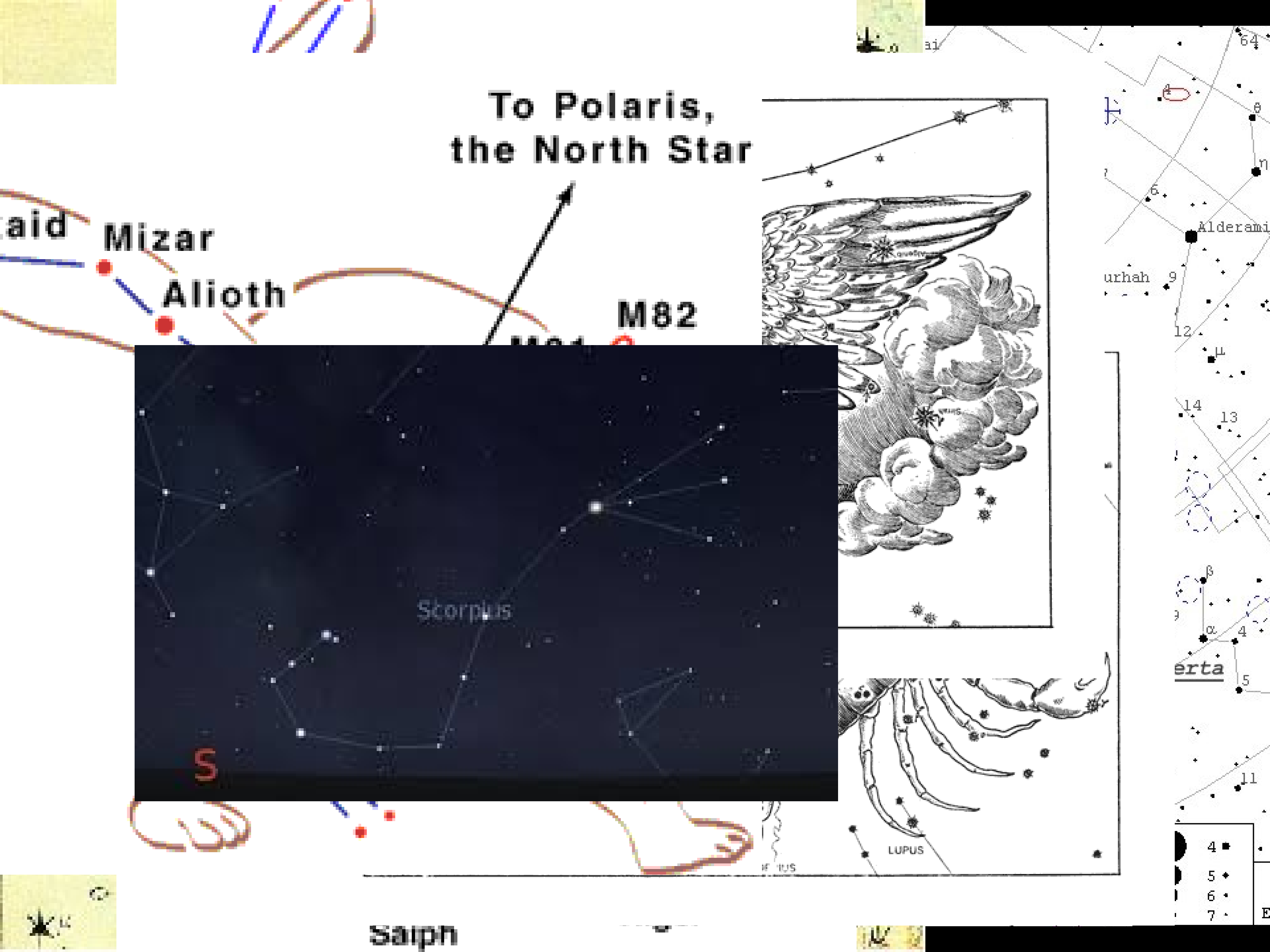
- For thousands of years, people have used the stars for a calendar and for navigation



Clusters vs constellations

- Constellations only *seem* close in the sky
- Clusters are stars that are truly grouped



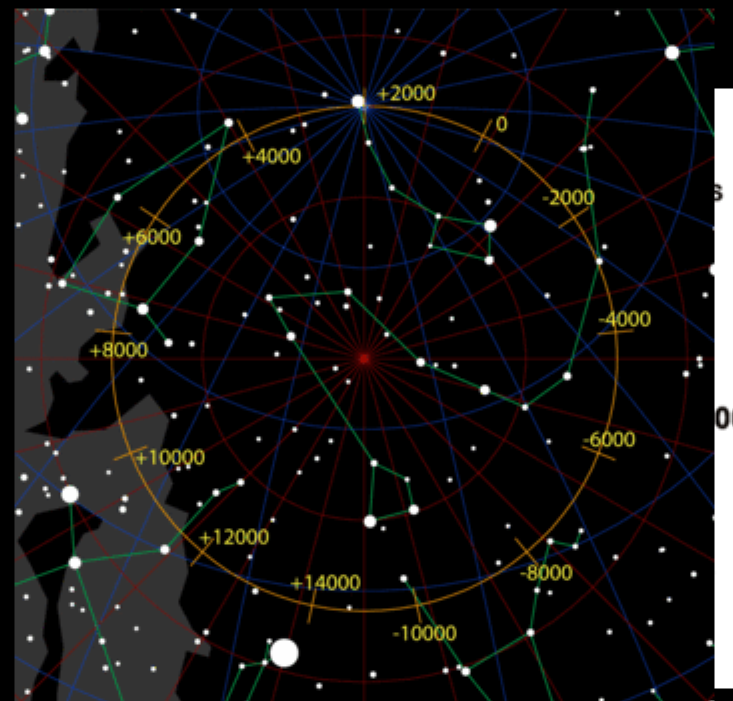
To Polaris,
the North Star
Mizar
Alioth
M82
Saiph
Scorpius
S
LUPUS

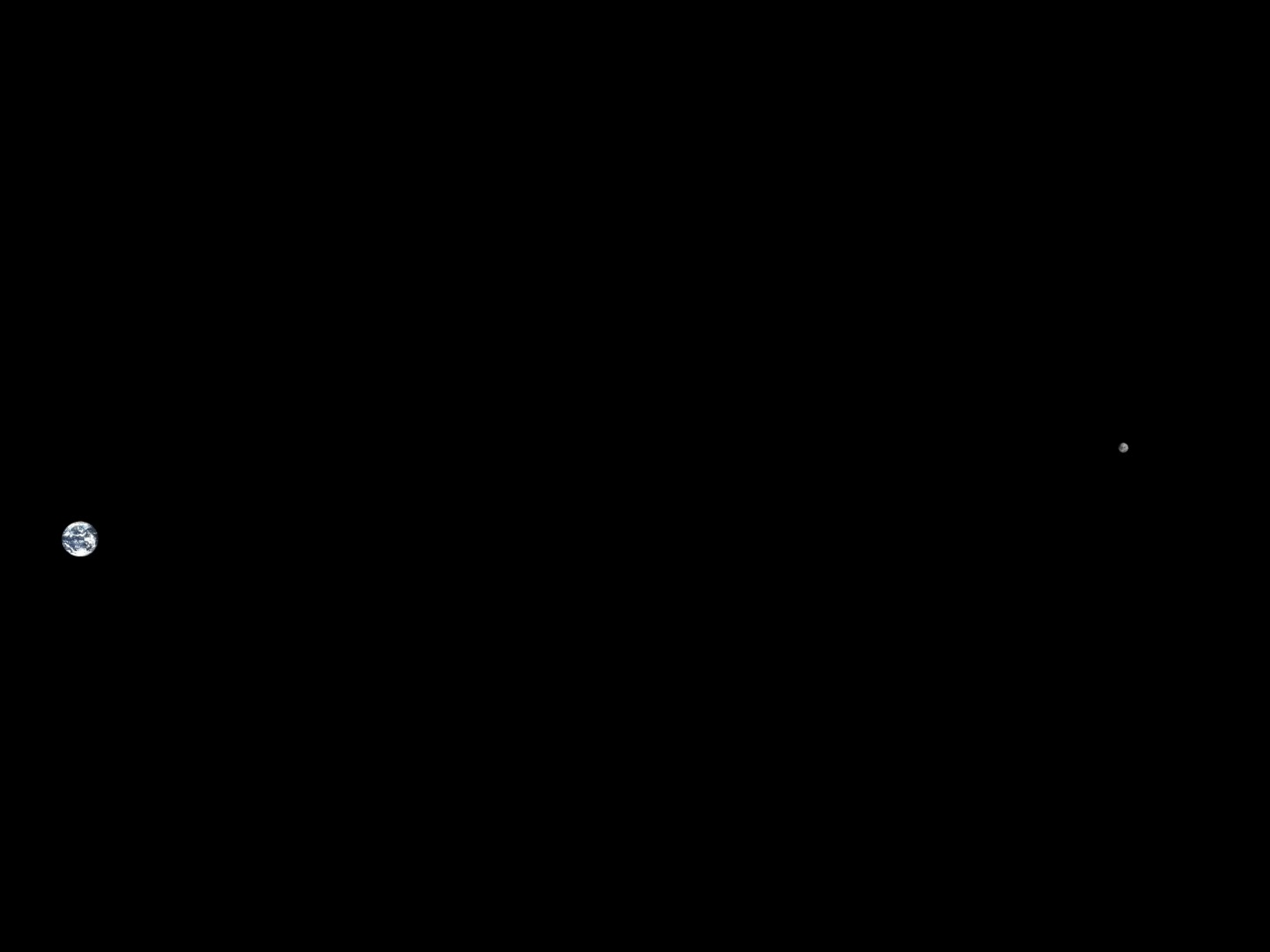
North Star

Why isn't there a "South Star"?

Precession

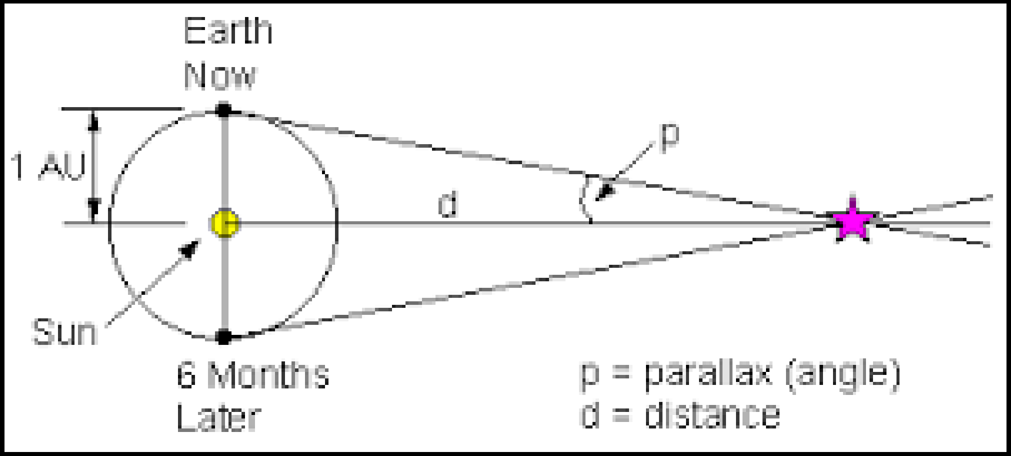
- The Earth's axis also precesses like a top's
- In 10,000 years, Vega will be the North Star

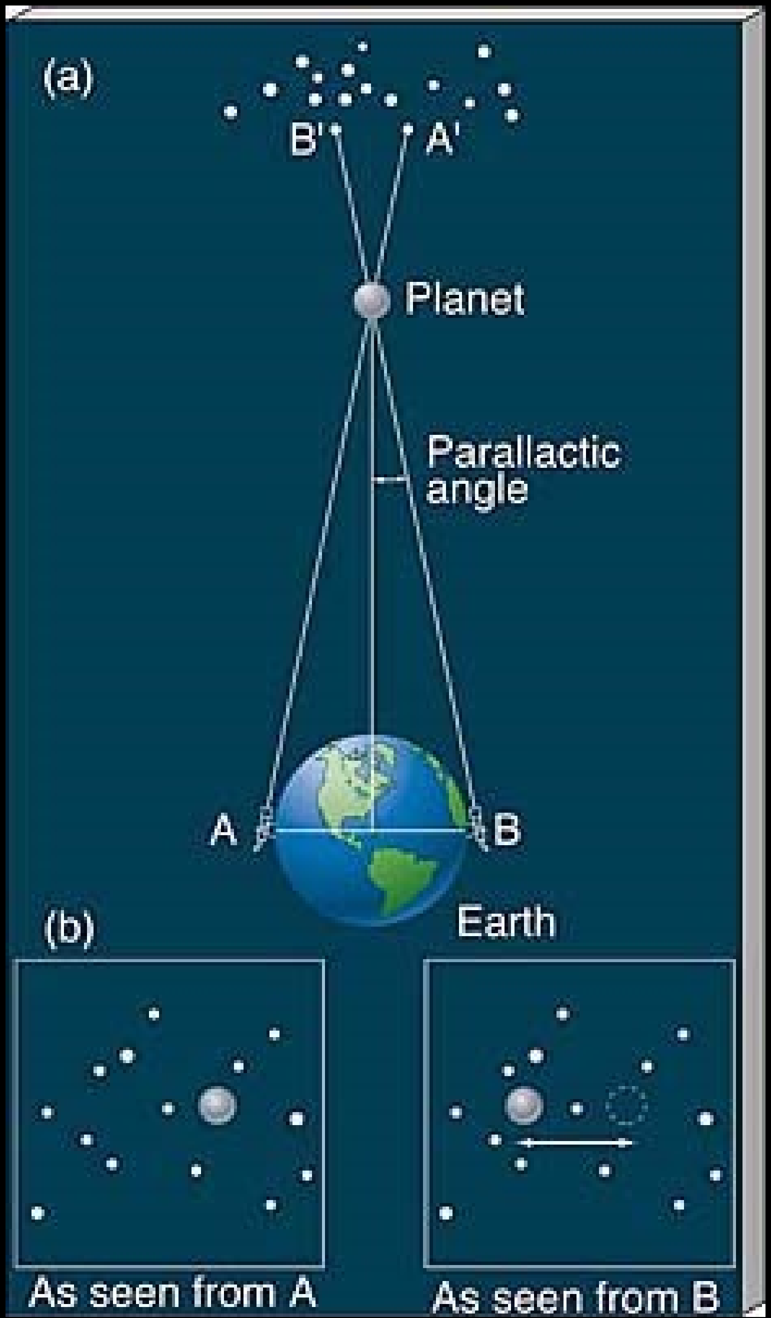


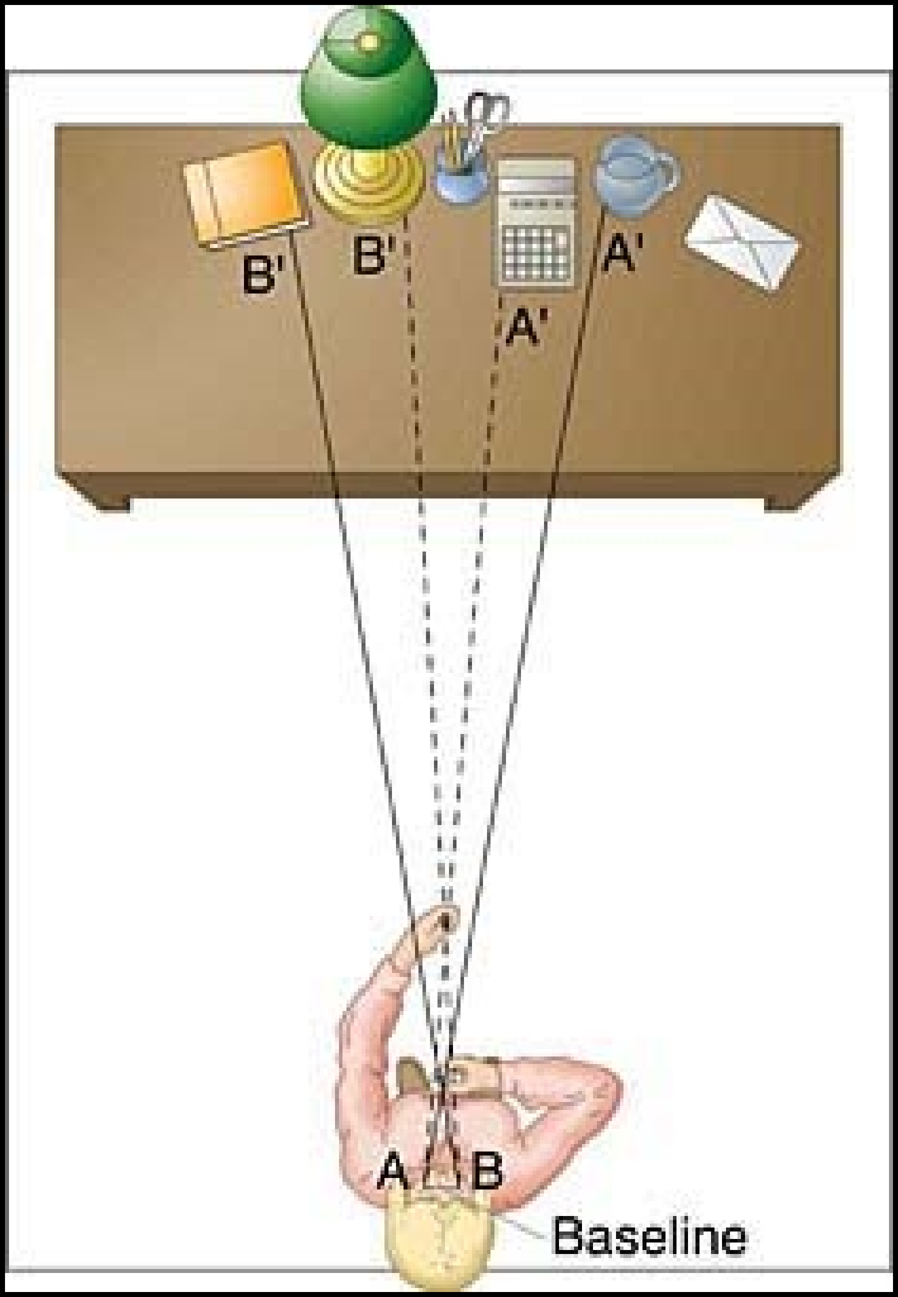


Parallax

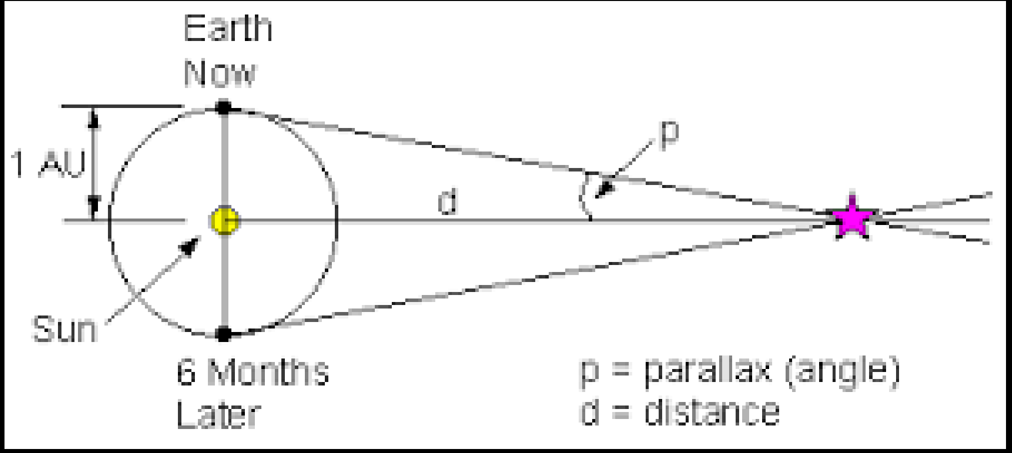
- When sighted from a different position, an object seems to change position relative to background stars.




(a)
B'
A'
Planet
Parallactic angle
A
B
Earth
(b)
As seen from A
As seen from B


B'
B'
A'
A'
A
B
Baseline

Parallax



- The distance in parsecs to a star with a parallax of p is:

$$d(\text{parsec}) = \frac{1}{p(arc - \text{sec})}$$

  - Ex: what is the distance to a star with a parallax of 0.23”?

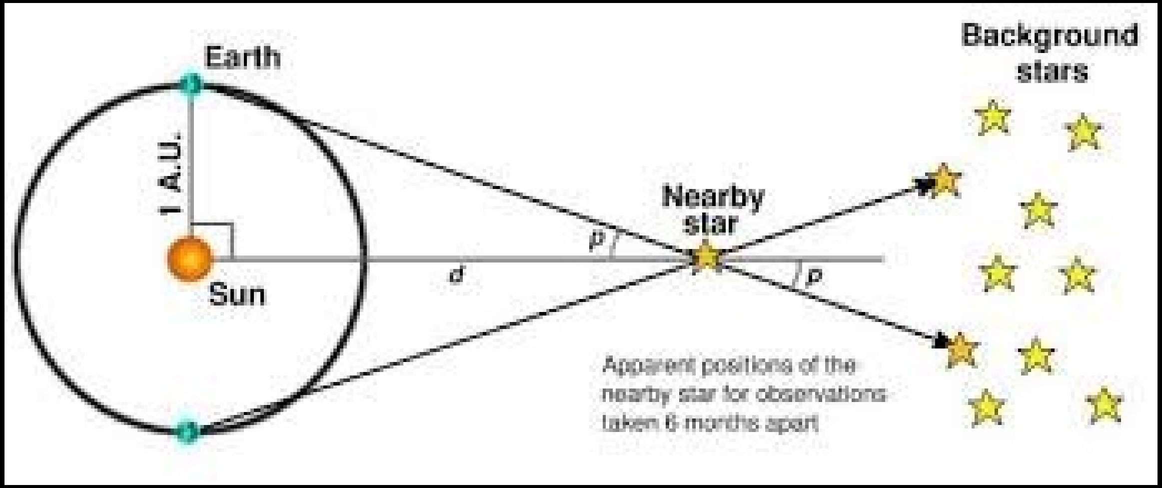
$$d(\text{parsec}) = \frac{1}{0.23} \quad = 4.3\,pc$$

Ex: measure the distance to the post

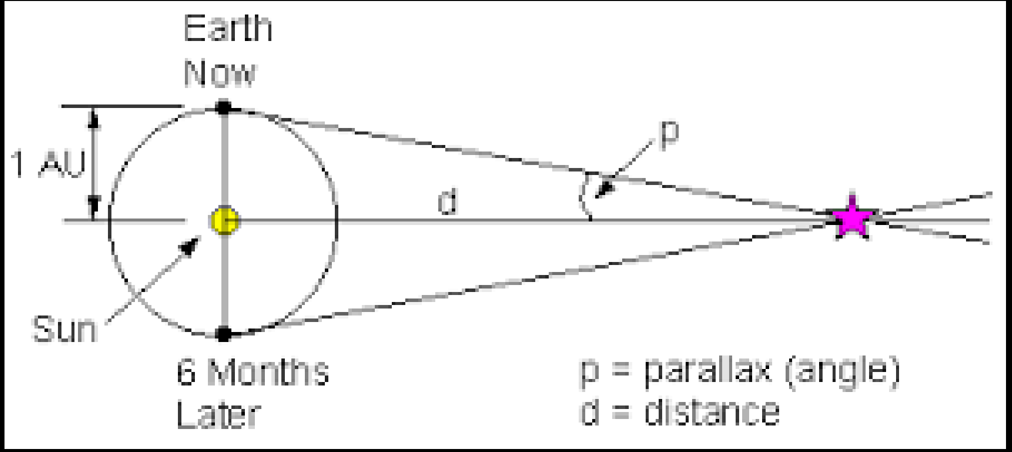
Comparing two pictures:

- Find the parallax angle from the separation relative to iPad total of 54º. Ex:
- $$Angle = \frac{2.1\text{cm}}{19.8\text{cm}} \cdot 54°$$

$$= \frac{5.7°}{2} = 2.86°\,parallax$$



$$d(\text{parsec}) = \frac{1}{p(arc-\sec)}$$



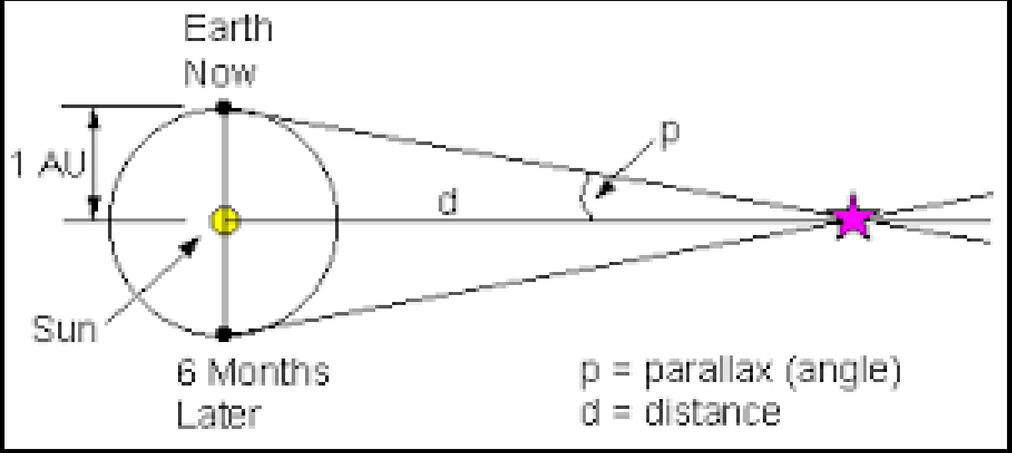
- Ex: what is the distance to a sign post with a parallax of 3º?
- 3º x60x60= 10800”

$$d = \frac{1}{10800} \quad = 9.3\times10^{-5}$$

- What if we didn’t move the earth’s orbital diameter?

$$9.3\times10^{-5}\times\frac{2m}{3\times10^{11}m} = 6.2\times10^{-16}\,pc\times3.26\times9.46\times10^{15} = 19m$$

$$d(\text{parsec}) = \frac{1}{p(arc - \sec)}$$



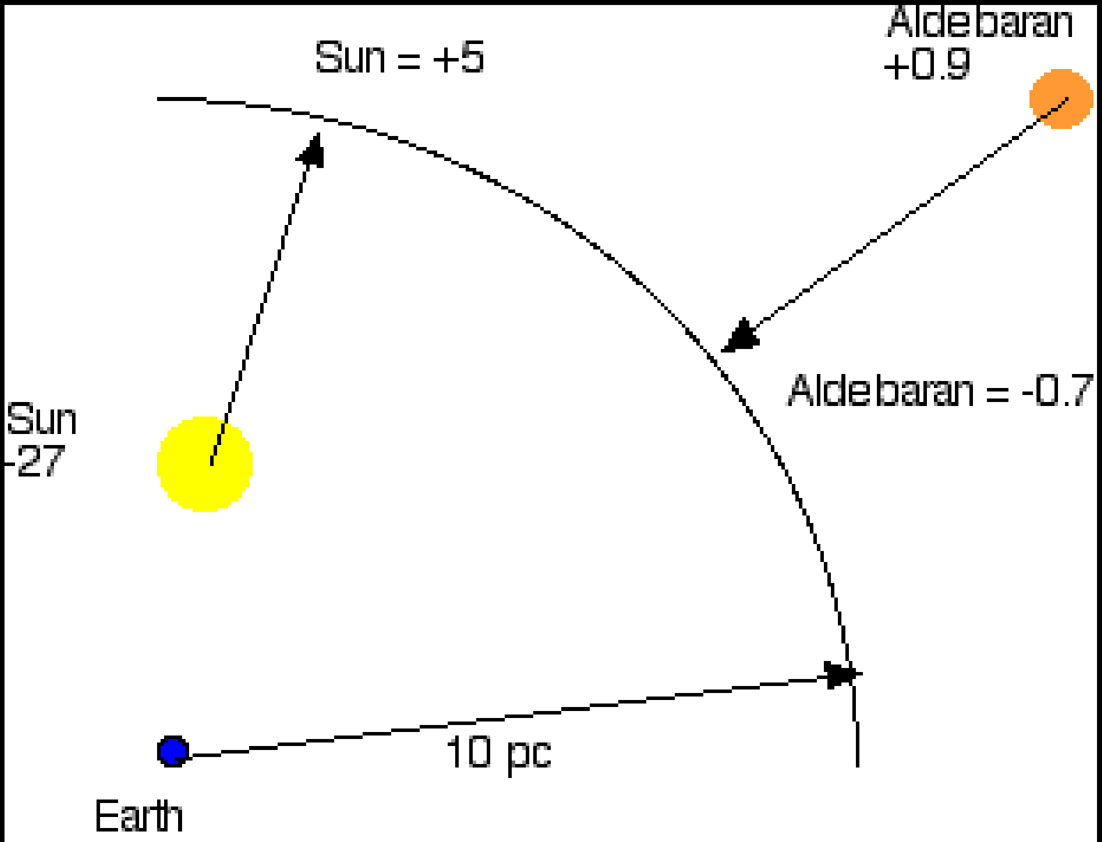
- Ex 1: what is the distance to a star with a parallax of
- A) 0.3”
- B) 0.06”
- C)The limit of 0.01”

$$d = \frac{1}{0.01} = 100\,pc$$

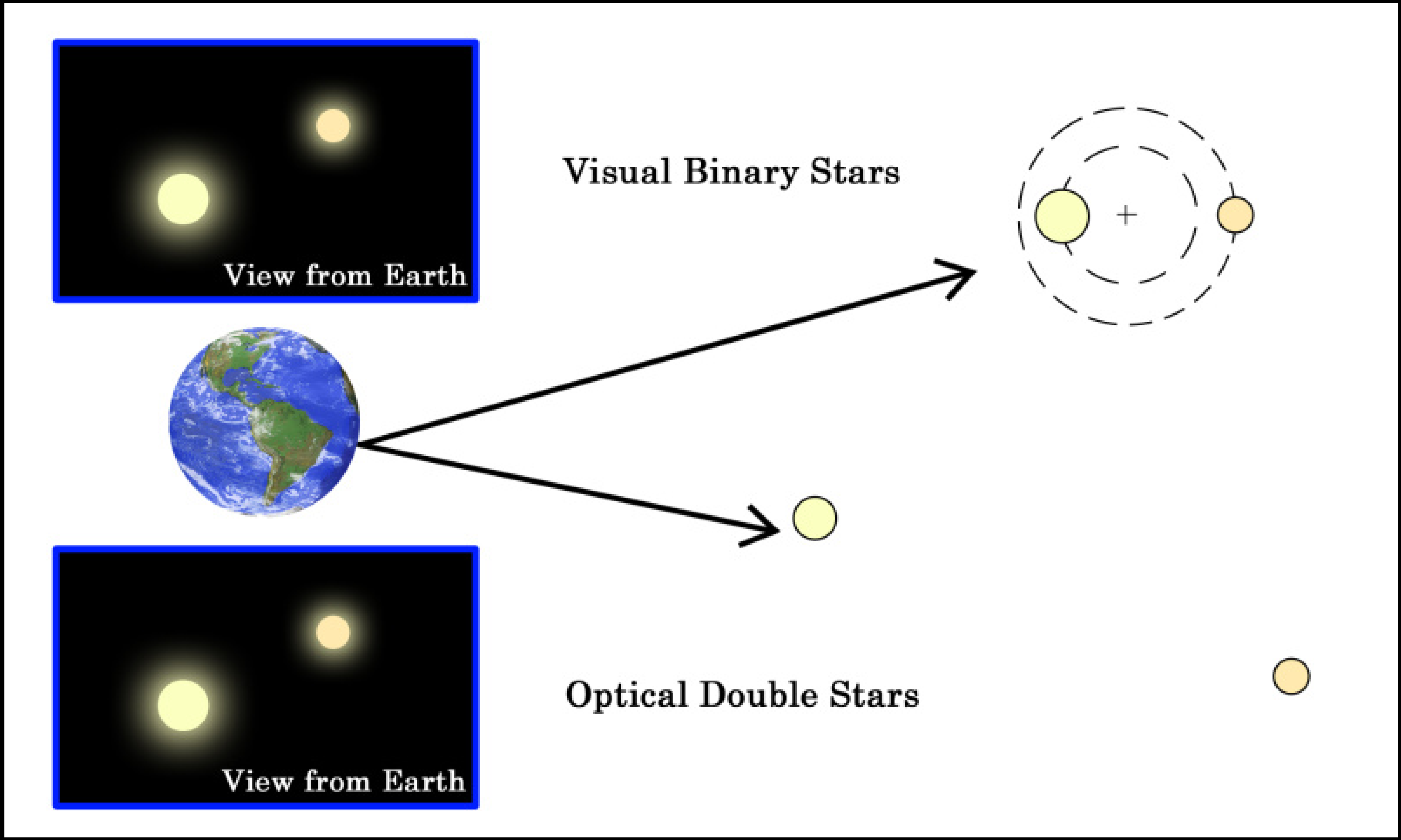
Magnitude

- We define stellar magnitude as brightness:
  - The brightest stars in the sky are classified as magnitude 1, then 2, to 5 for the dimmest stars we can see
  - But are these brighter stars really brighter or just closer?

- For this reason we separate:
  - Apparent magnitude
    - How bright a star looks in the sky
  - Absolute magnitude
    - How bright stars would look if they were all 10pc away

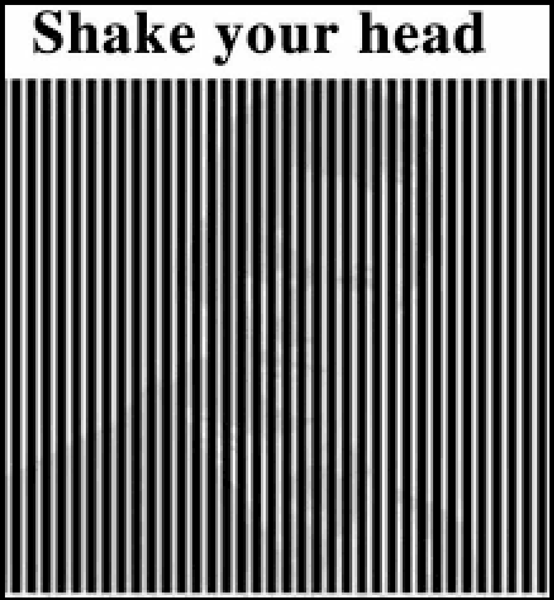


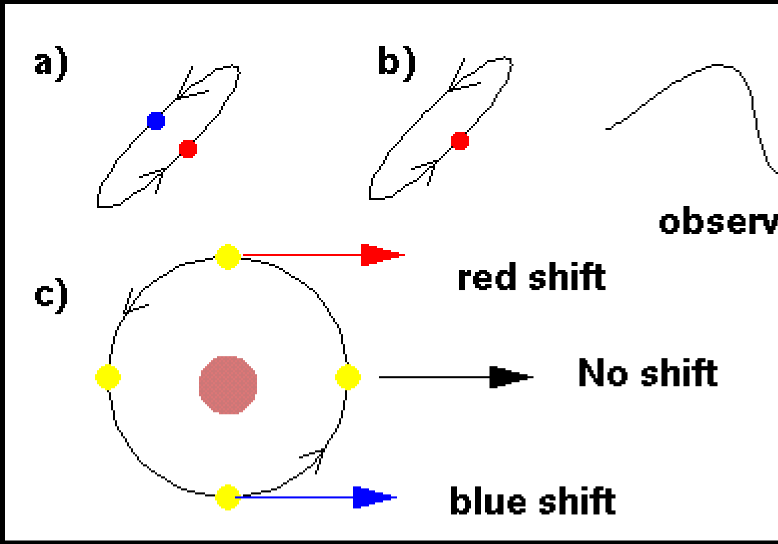
Optical or visual?



Binary Stars

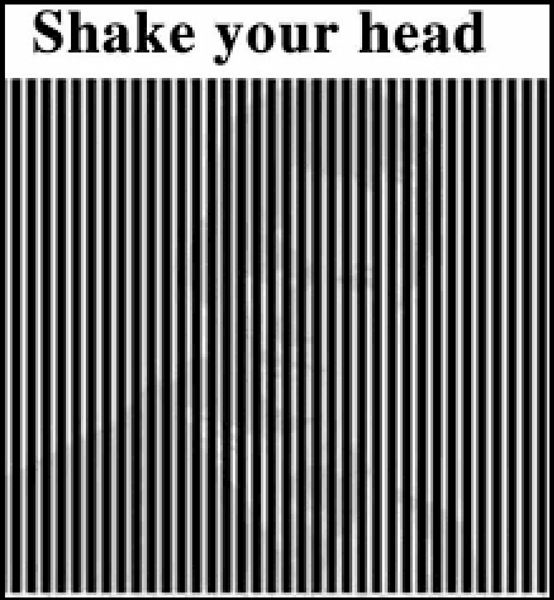
- Do your own research. Define the following:
  - Optical binaries
  - Visual binaries
  - Eclipsing binaries
  - Spectroscopic binaries

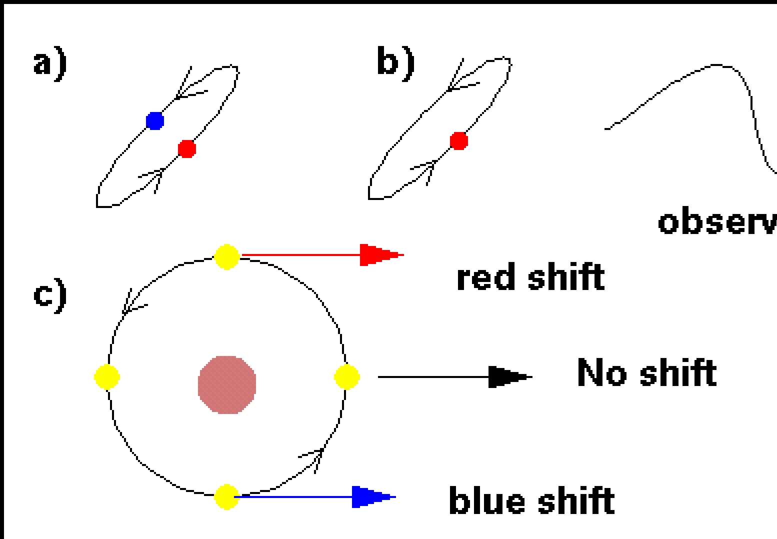




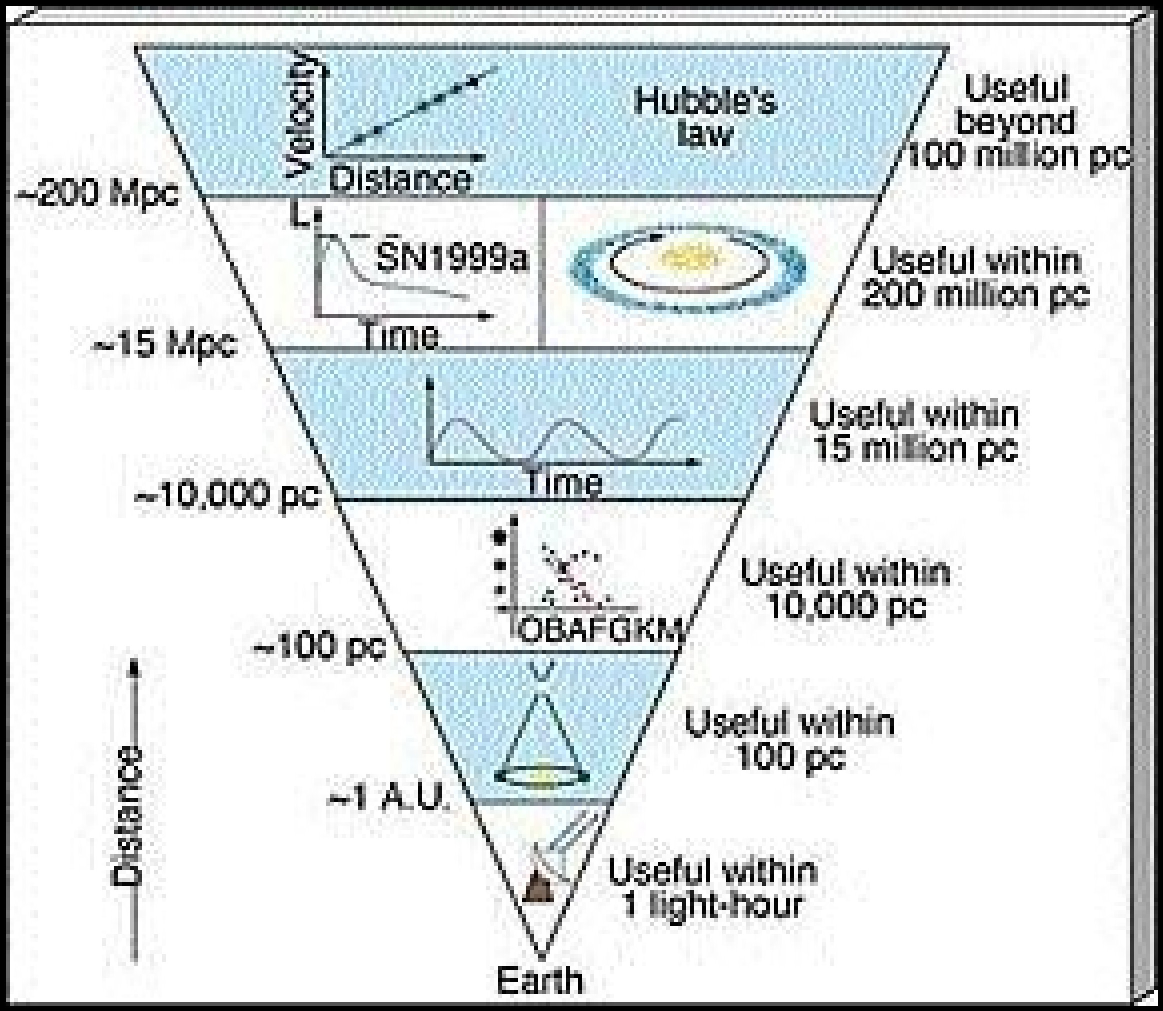
Binary Stars

- Optical (illusion) binaries only look like they are paired
- Visual binaries are actually orbiting each other
- If we are looking edge-on, we get eclipsing binaries
- We can analyse shifts of spectroscopic binaries





The distance ladder

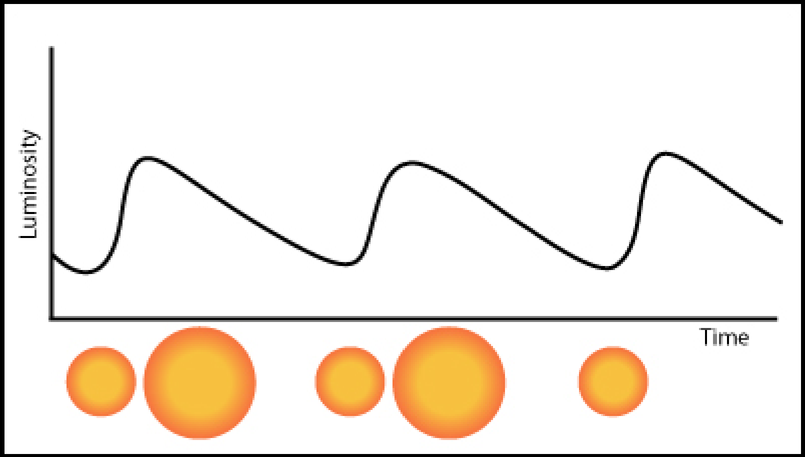


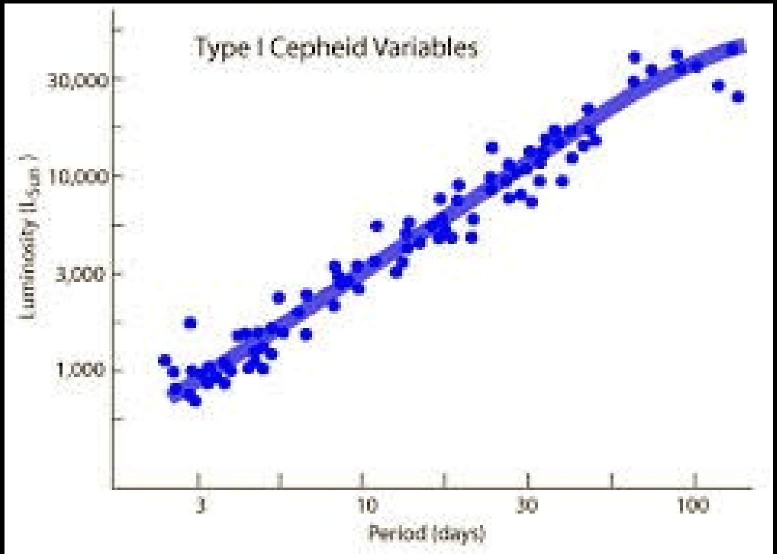
How do we know the distances to stars and galaxies?

- For close (<100pc) stars, we can use parallax
- For distant stars and galaxies we need another method
- If only we knew the luminosity of some reference stars AKA a "standard candle"

Cepheid Variables

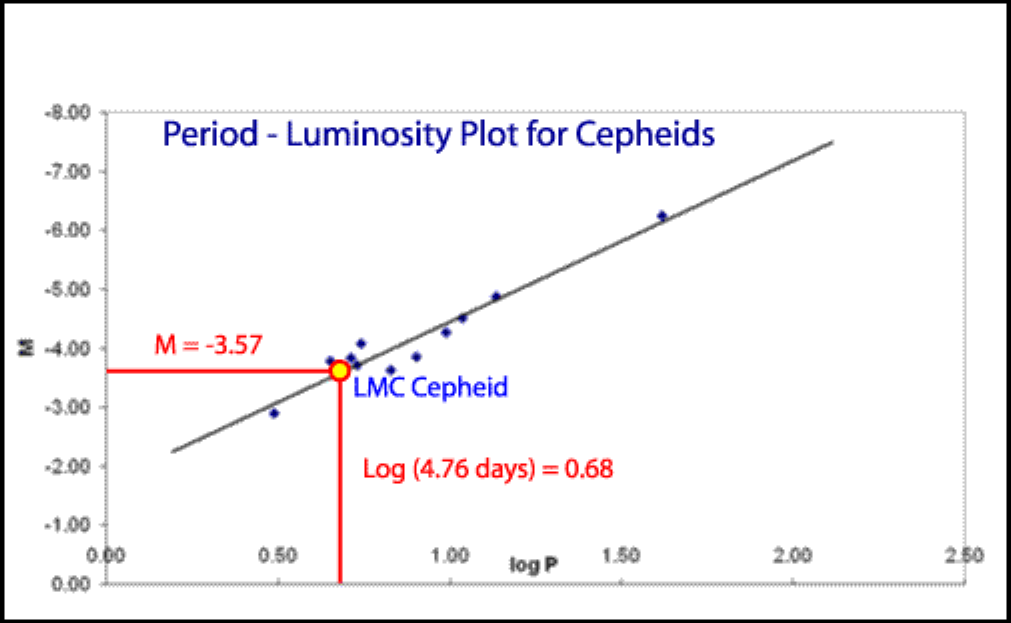
- These stars' gases are unstable and so they expand and contract
- The period gives Luminosity
- C.f. RR Lyrae stars, Wolf Rayet stars





Cepheid Variables

- The longer the period, the brighter the star
- This allows us to calculate the distance



- Ex 1: what is the apparent brightness of a 250 W heat lamp from 5 m away?

$$b = \frac{L}{4\pi d^2}$$

$$b = \frac{250\text{W}}{4\pi(5m)^2}$$

$$b = 0.80W \cdot m^{-2}$$

- Ex 1: What is the power of a light bulb that has the same brightness for Mary(2m away)?

$$b = \frac{L}{4\pi d^2}$$

$$L = 4\pi d^2 b$$

$$L = 4\pi 2^2 0.8$$

$$= 40W$$

- Ex 3: How much more luminous is star x, which is twice as bright as Polaris, and 3 times further away?

$$b = \frac{\mathrm{L}}{4\pi d^2}$$

$$\frac{b_x}{b_p} = \frac{\mathrm{L_x}}{4\pi d_x^{\,2}} \div \frac{\mathrm{L_p}}{4\pi d_p^{\,2}}$$

$$\frac{b_x}{b_p} = \frac{\mathrm{L_x}}{4\pi d_x^{\,2}} \cdot \frac{4\pi d_p^{\,2}}{\mathrm{L_p}}$$

$$\frac{b_x}{b_p} = \frac{\mathrm{L_x}}{\mathrm{L_p}} \cdot \frac{d_p^{\,2}}{d_x^{\,2}}$$

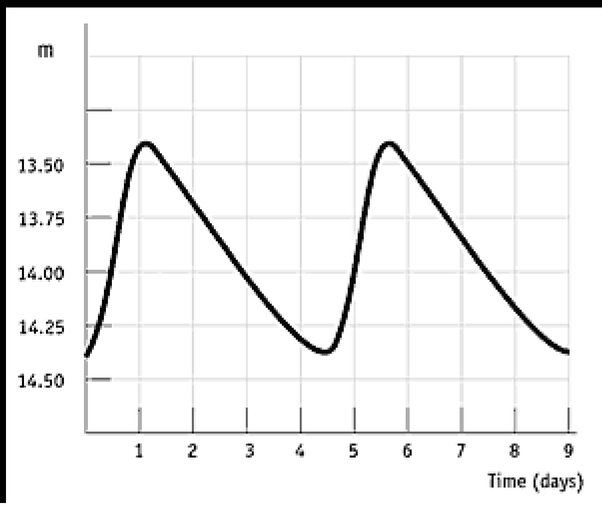
$$\frac{b_x}{b_p} \cdot \frac{d_x^{\,2}}{d_p^{\,2}} = \frac{\mathrm{L_x}}{\mathrm{L_p}}$$

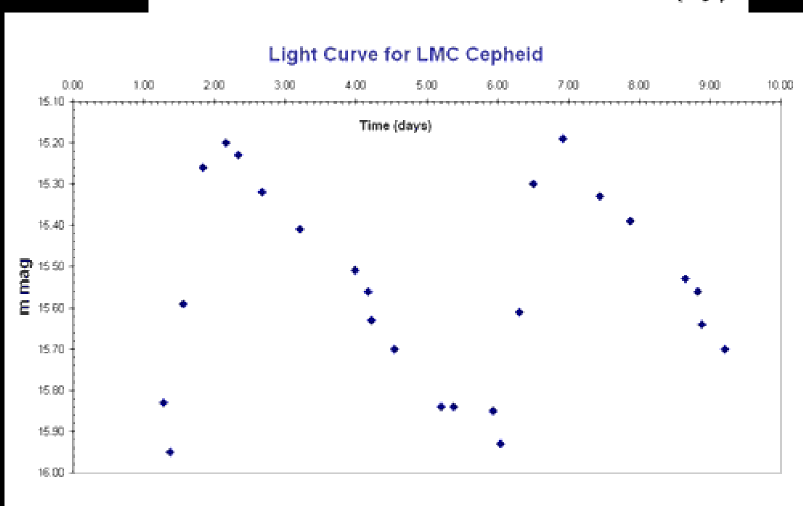
$$\frac{2b_p}{b_p} \cdot \frac{(3d_p)^2}{d_p^{\,2}} = \frac{\mathrm{L_x}}{\mathrm{L_p}}$$

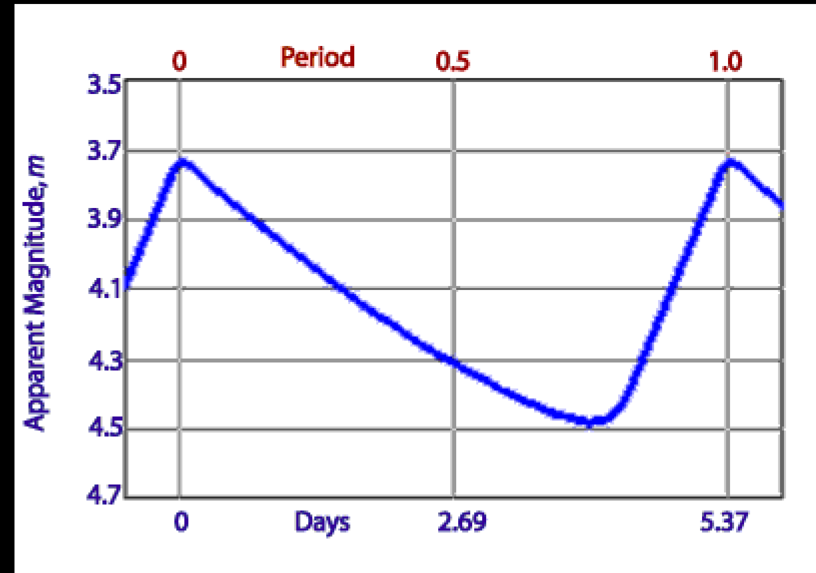
$$\frac{\mathrm{L_x}}{\mathrm{L_p}} = 18$$

$$\mathrm{L_x} = 18\mathrm{L_p}$$

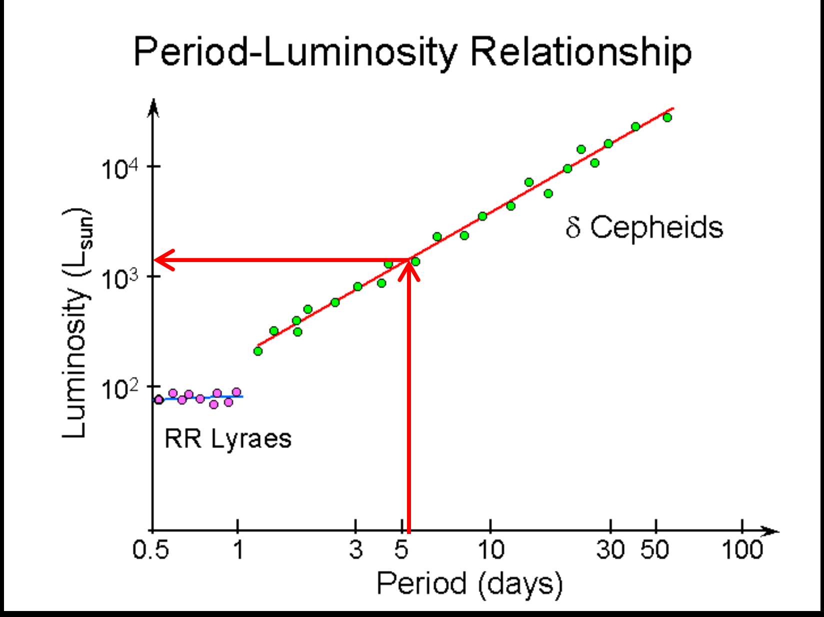
Ex: find the distance to the Cepheids below if $b = 4.5\times10^{-15}\ \mathrm{W\cdot m^{-2}}$







Light Curve for δ Cephei



- Ex 1: what is the distance to a star (compared to Sol) with 2000 solar luminosity and a brightness of $b = 4.5 \times 10^{-15}$ W m^{-2}

$$\boxed{b = \frac{L}{4\pi d^2}} \qquad \boxed{d = \sqrt{\frac{L}{4\pi b}}}$$

$$\boxed{\frac{d_c}{d_s} = \sqrt{\frac{L_c}{L_s}\frac{b_s}{b_c}}} \boxed{= \sqrt{\frac{2000(1360)}{4.5\times 10^{-15}}}} \boxed{= 2.5\times 10^{10}}$$

$$\boxed{d_c = 2.5\times 10^{10}\, AU}$$

Start R&D Questions

- Choose 7 of #1-10 p. 30
- Also start Vocab definitions: choose 5 words from Summary p. 29-30