Chapter 9:
Measuring the Stars

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AST 1002

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Astronomy vs. Cosmology

Dictionary

astronomy

as·tron·o·my
/əˈstränəmē/

noun

the branch of science that deals with celestial objects, space, and the physical universe as a whole.

Study of everything in the Universe

Study of large scale structure of the Universe

Dictionary

cosmology

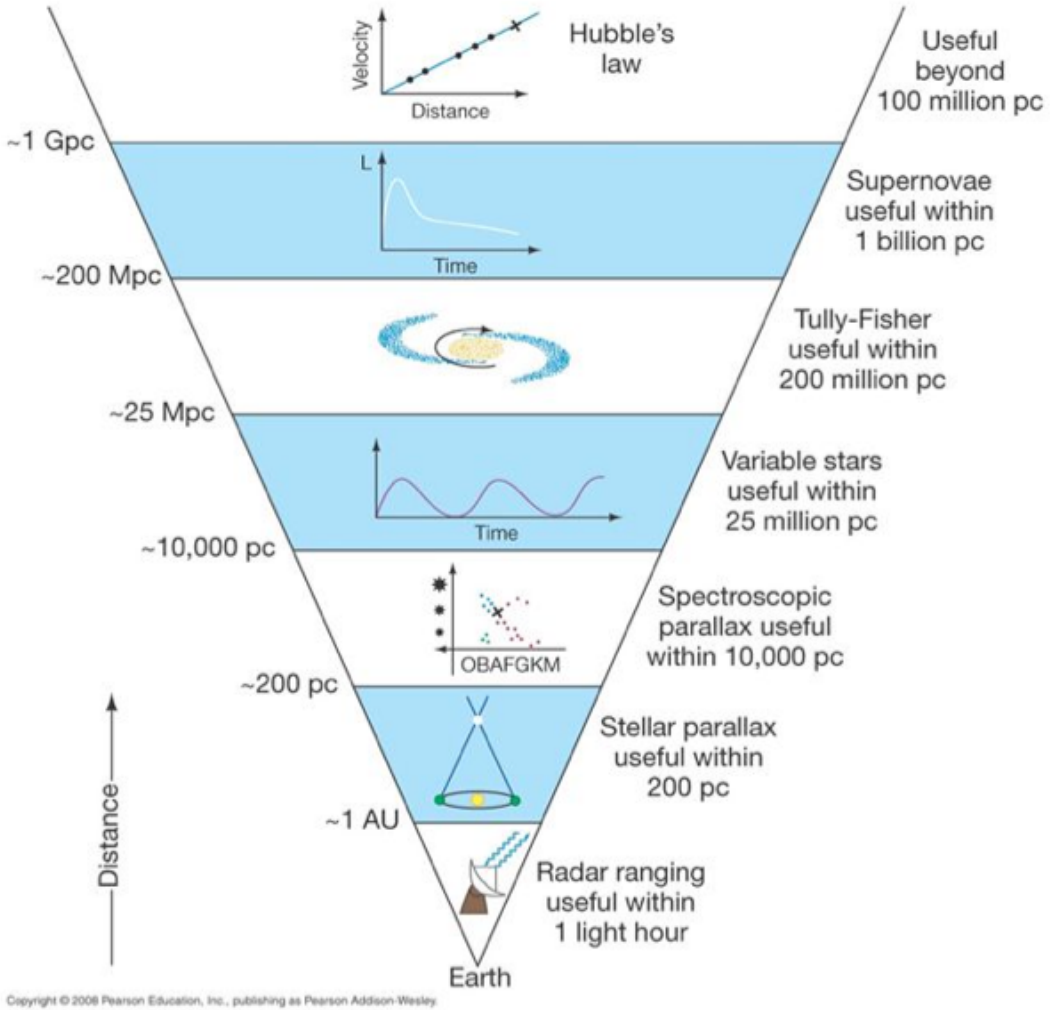
cos·mol·o·gy
/käzˈmäləjē/

noun

the science of the origin and development of the universe. Modern astronomy is dominated by the Big Bang theory, which brings together observational astronomy and particle physics.

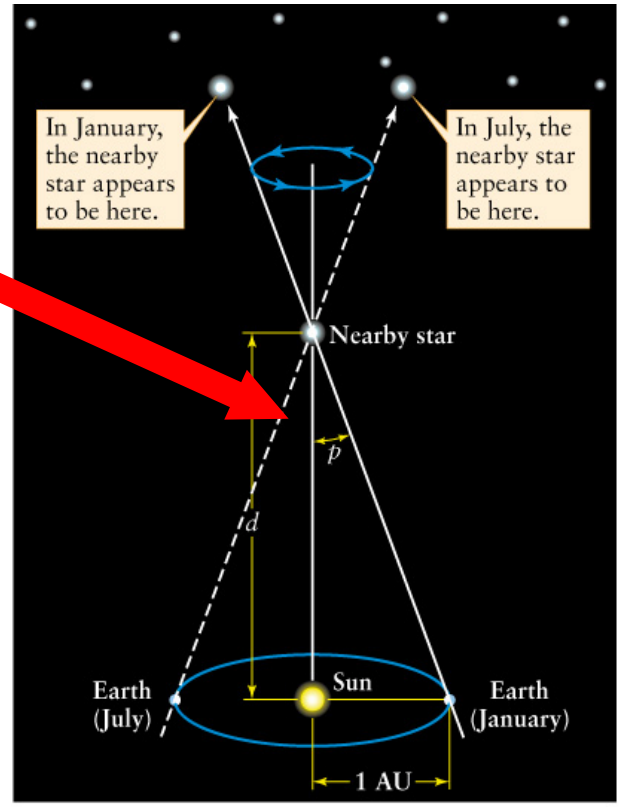
- an account or theory of the origin of the universe.
  plural noun: **cosmologies**

Cosmic Distance Ladder

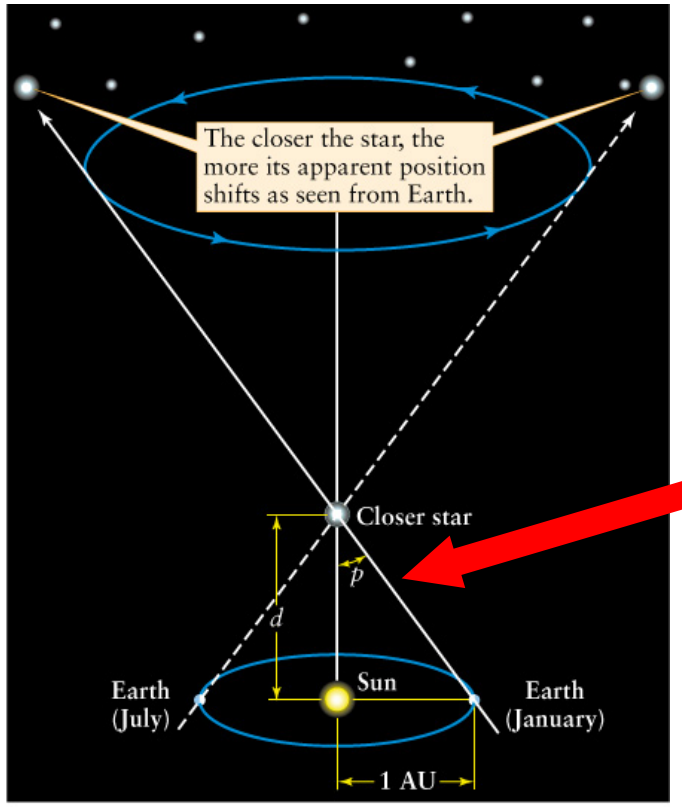


Stellar Parallax

Smaller parallax
→ larger distance



(a) Parallax of a nearby star



(b) Parallax of an even closer star

Larger parallax
→ smaller distance

Stellar Parallax Calculations

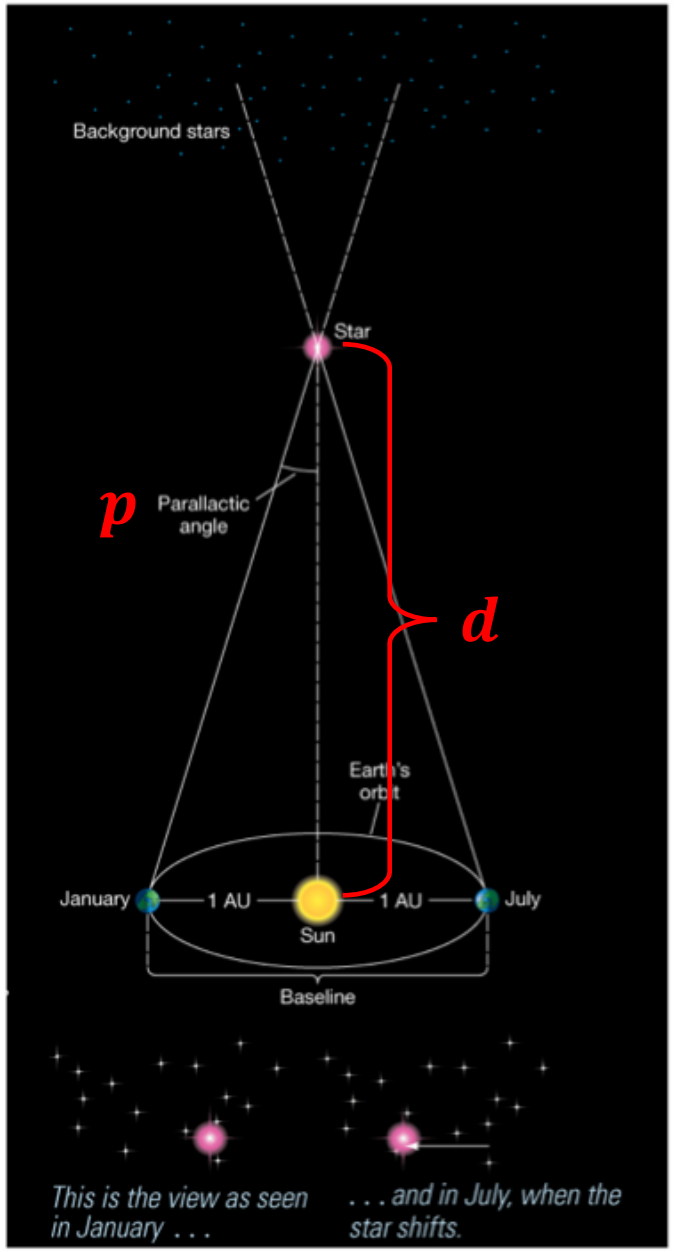
$$d = \frac{1}{p}$$

Distance in parsecs (pc)

Angle in arcseconds (")

$$1 \text{ pc} = 3.26 \text{ ly}$$

Same order of magnitude!

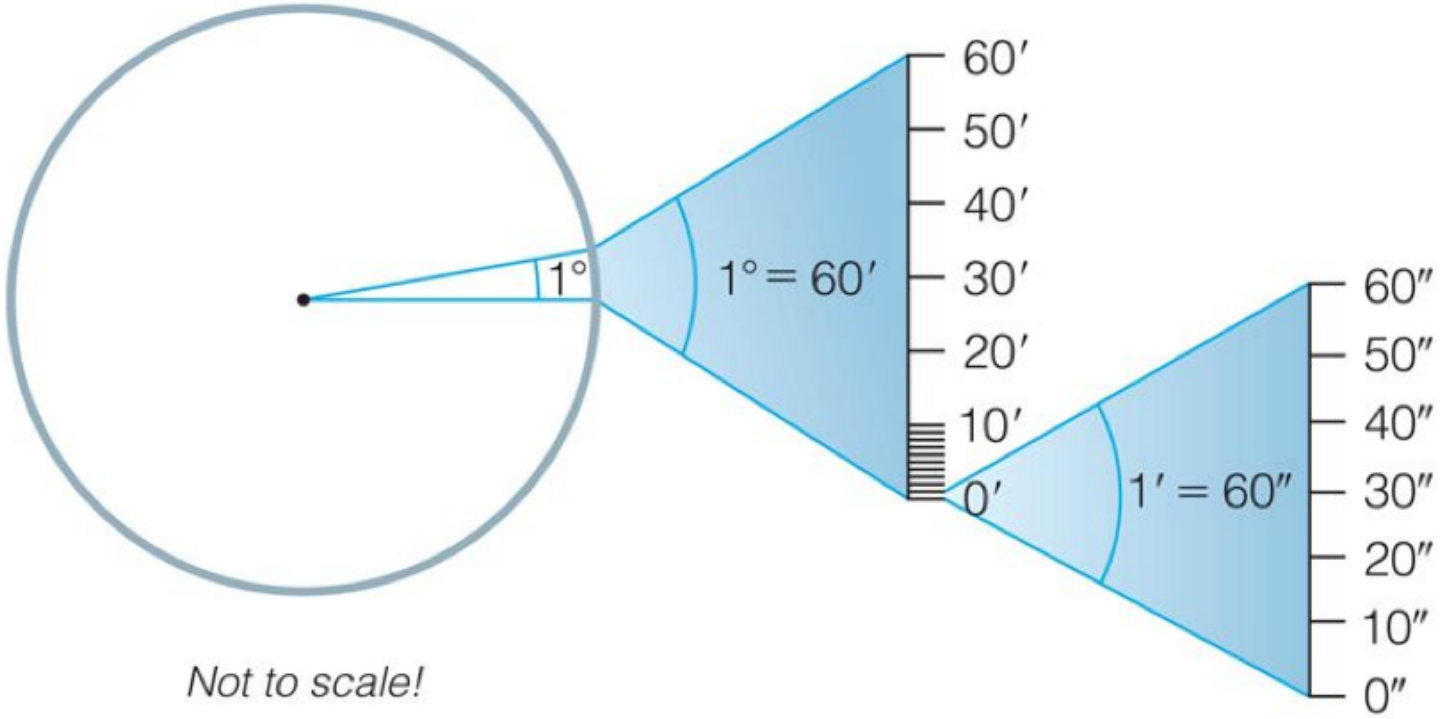


Arcminutes and Arcseconds

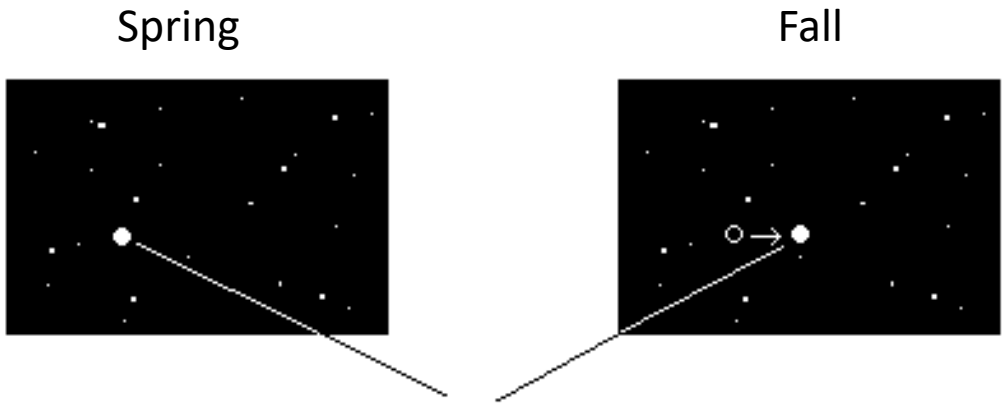
$$1 \text{ circle} = 360^o$$

$$1^o = 60'$$

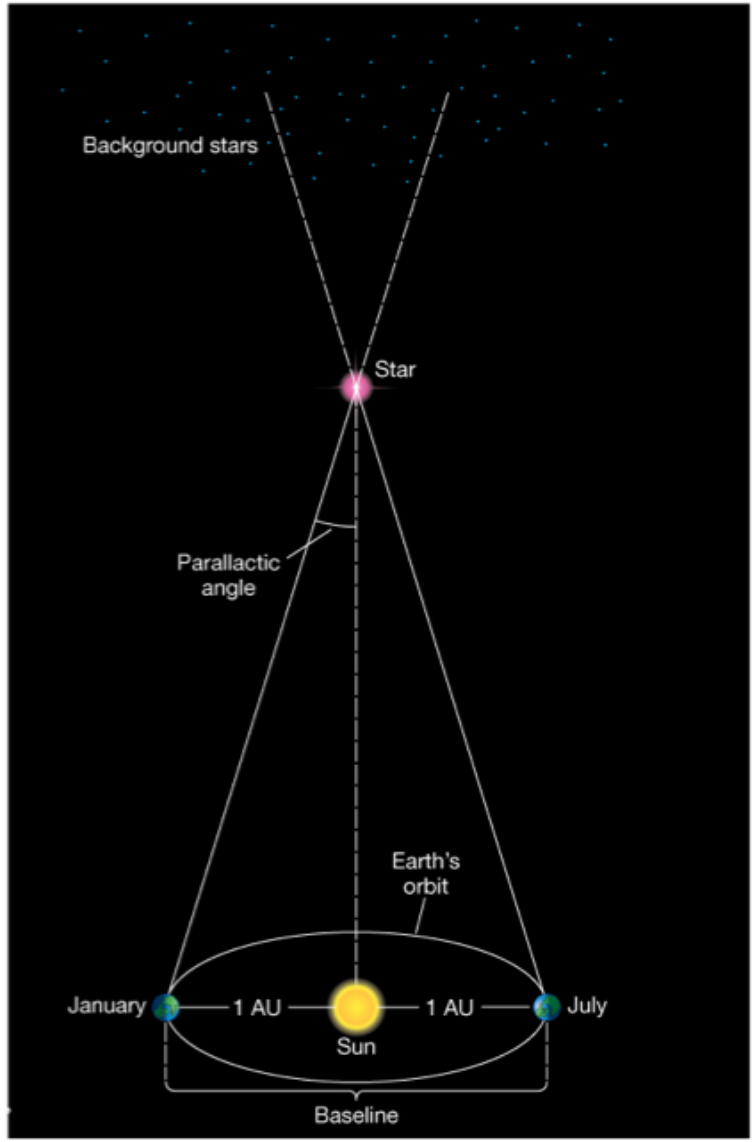
$$1' = 60''$$



Measuring Parallax



$$d = \frac{1}{p} = \frac{1}{0.25''} = 4\text{pc}$$



Limits of Parallax

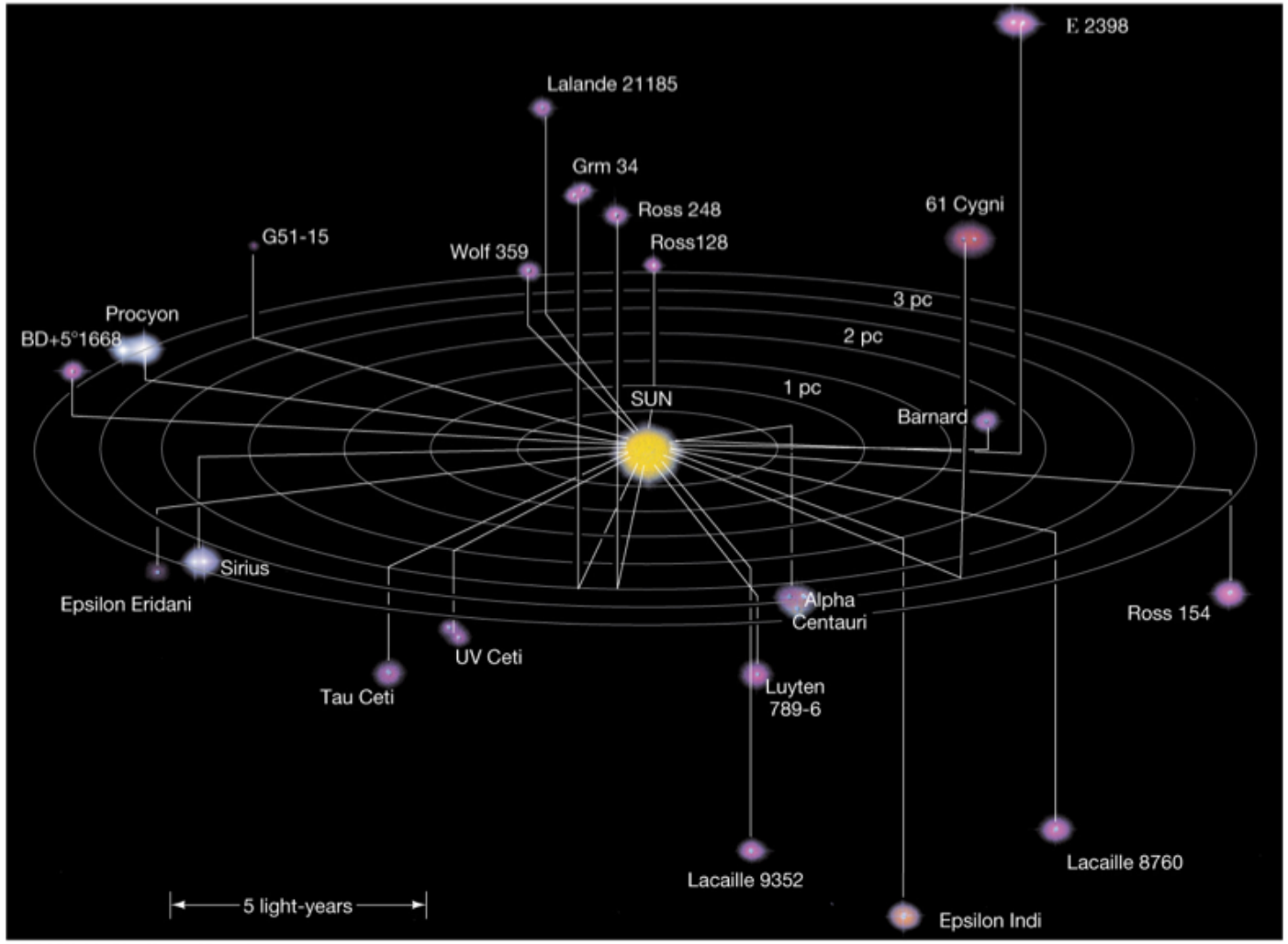
Angles smaller than 0.01'' are hard to measure from Earth

$$d_{\max} = \frac{1}{0.01''} = 100\text{pc}$$

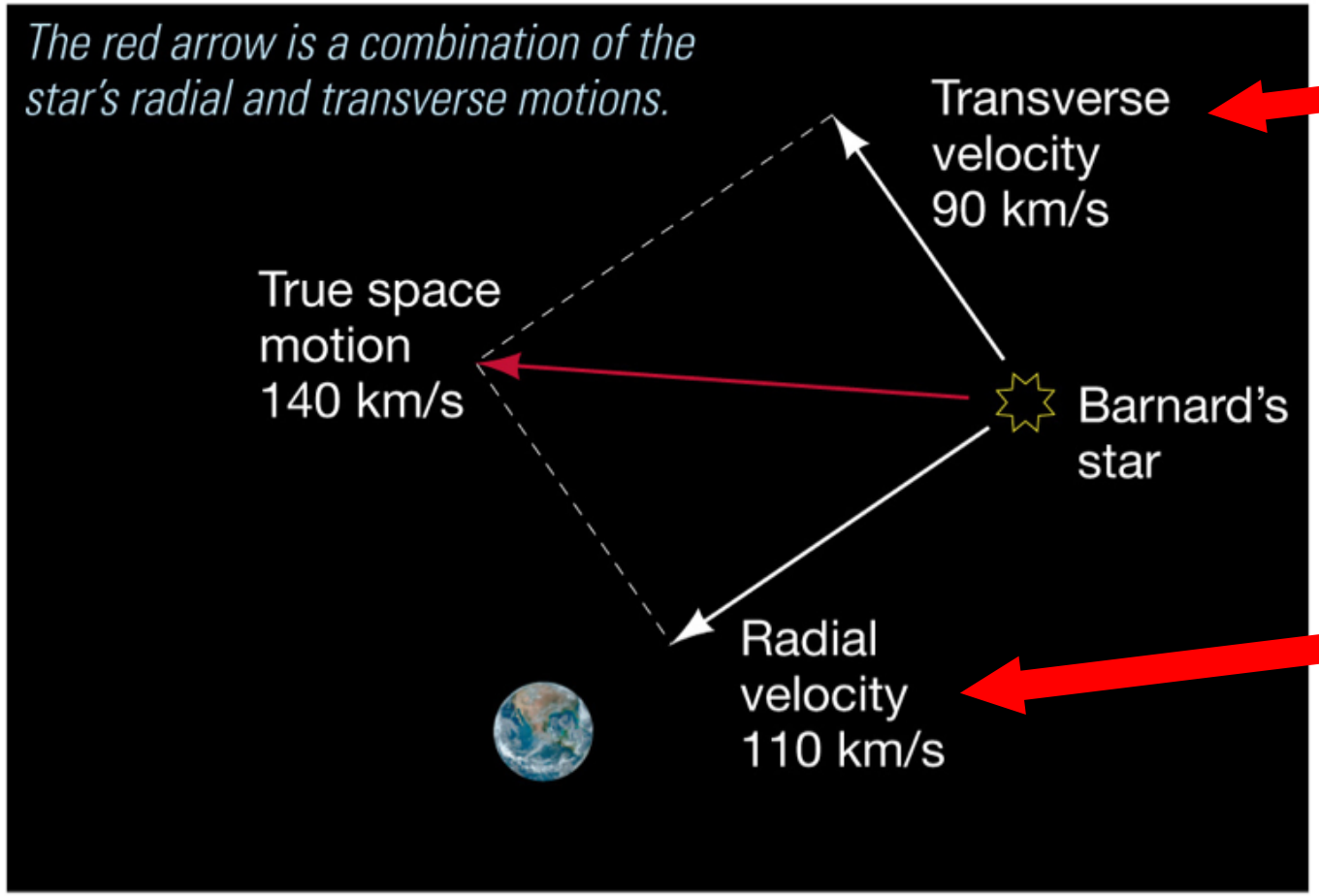
Angles smaller than 0.001'' are hard to measure from Space

$$d_{\max} = \frac{1}{0.001''} = 1000\text{pc}$$

Nearest Neighbors



Motion of Stars



Found using geometry

Found using Doppler Effect

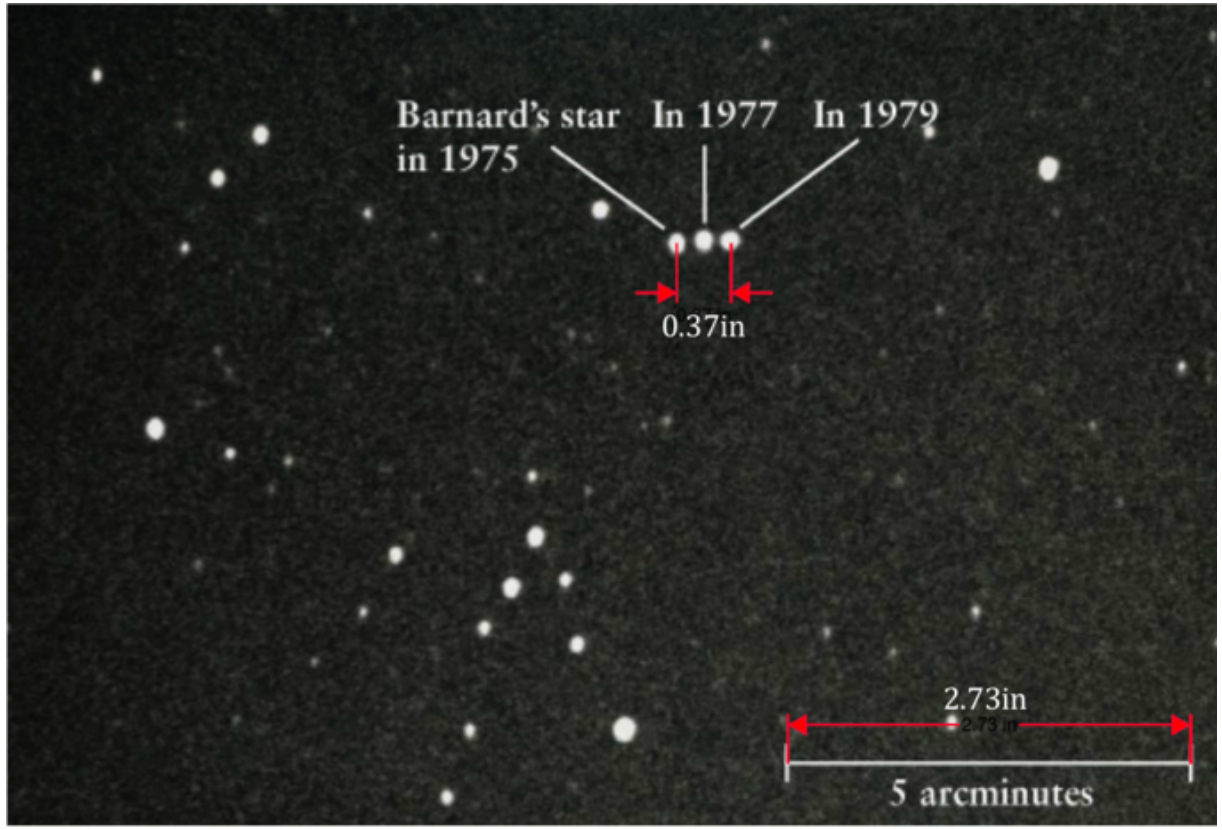
Translational Motion

Distance traveled (arcsec/year)

$$v_t = 4.74\mu d$$

Transverse velocity (km/s)

Distance to star (pc)



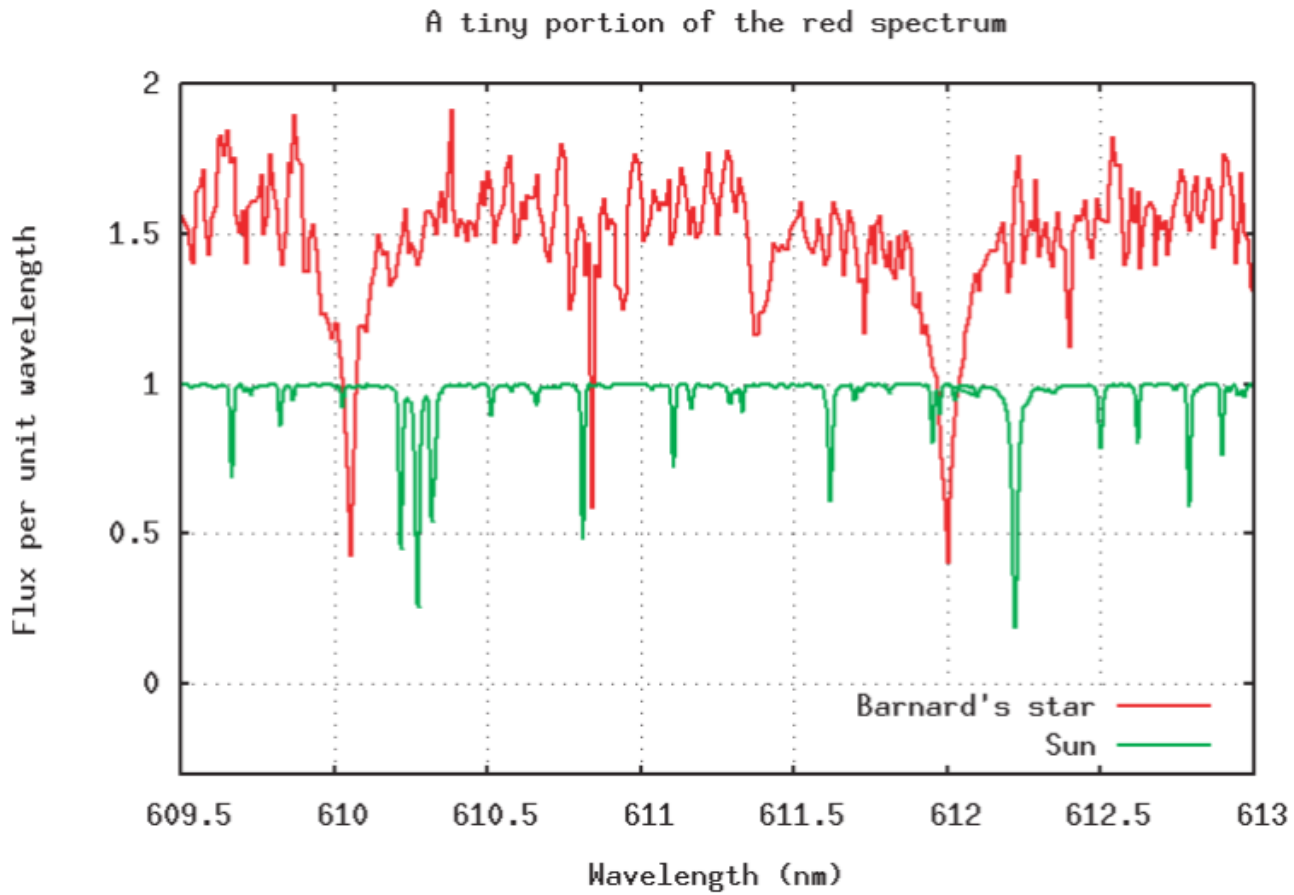
Radial Motion

Shifted wavelength

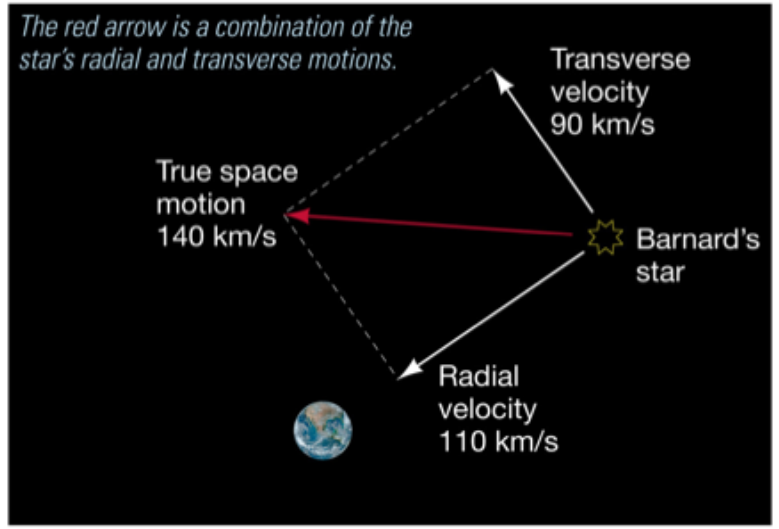
$$\frac{\lambda}{\lambda_0} - 1 = \frac{v_r}{c}$$

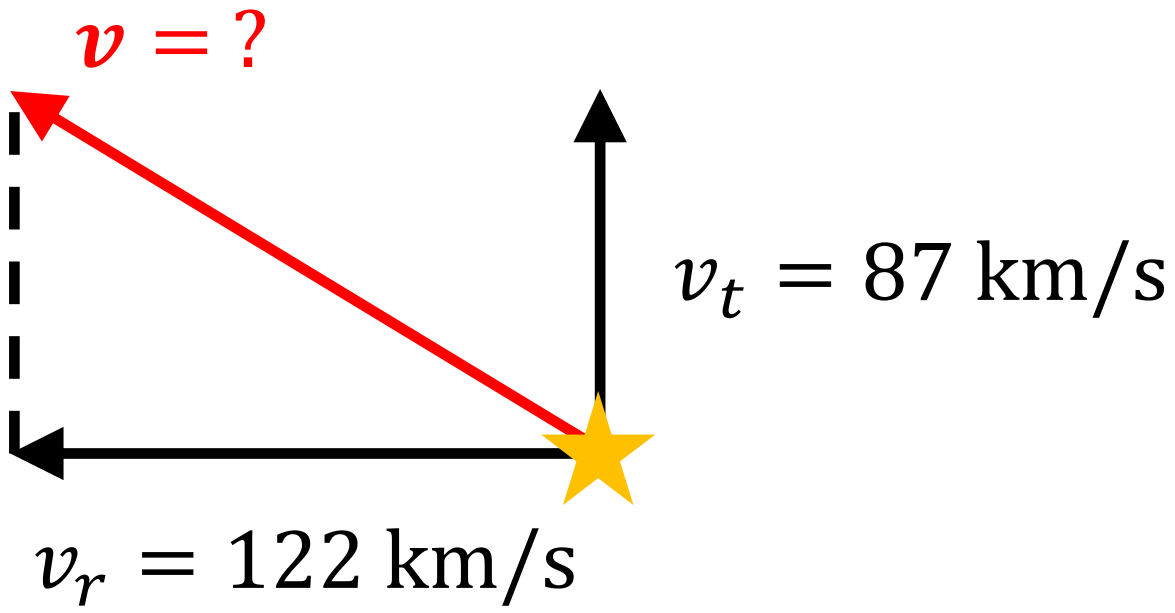
Proper wavelength

Figure 1: Barnard Star and Sun's Spectrum



Total Motion



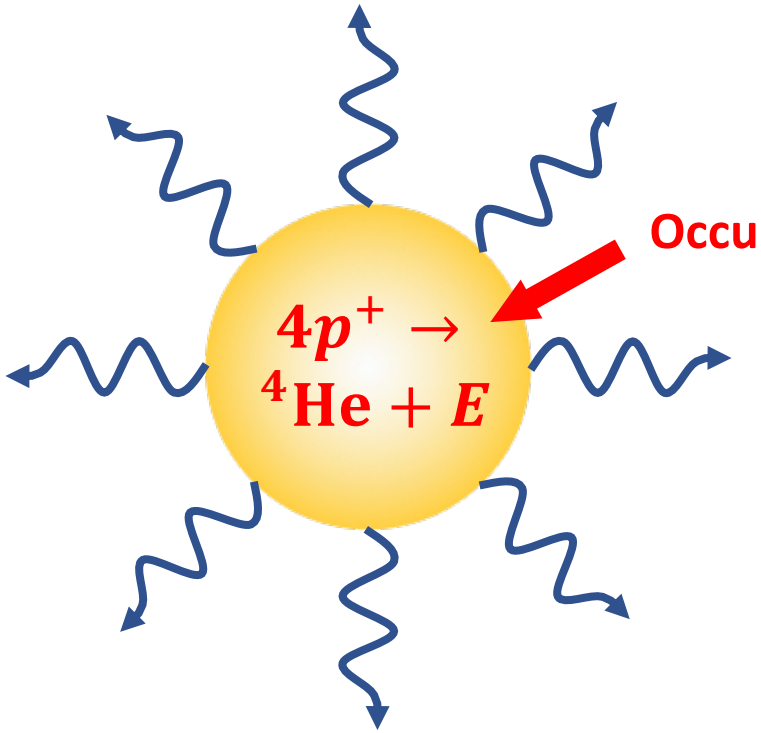


Luminosity

Brightness is what we call **Luminosity**, L

→ It's the amount of energy released per second (Watts, W)

→ It's an **inherent quantity** of a star



Occurs 9.58×10^{37} times every second

$$L_\odot = 3.828\times10^{26}\ \mathrm{W}$$

$\odot$ = Sun

Flux

We don't measure the brightness of a star, but it's **apparent brightness**

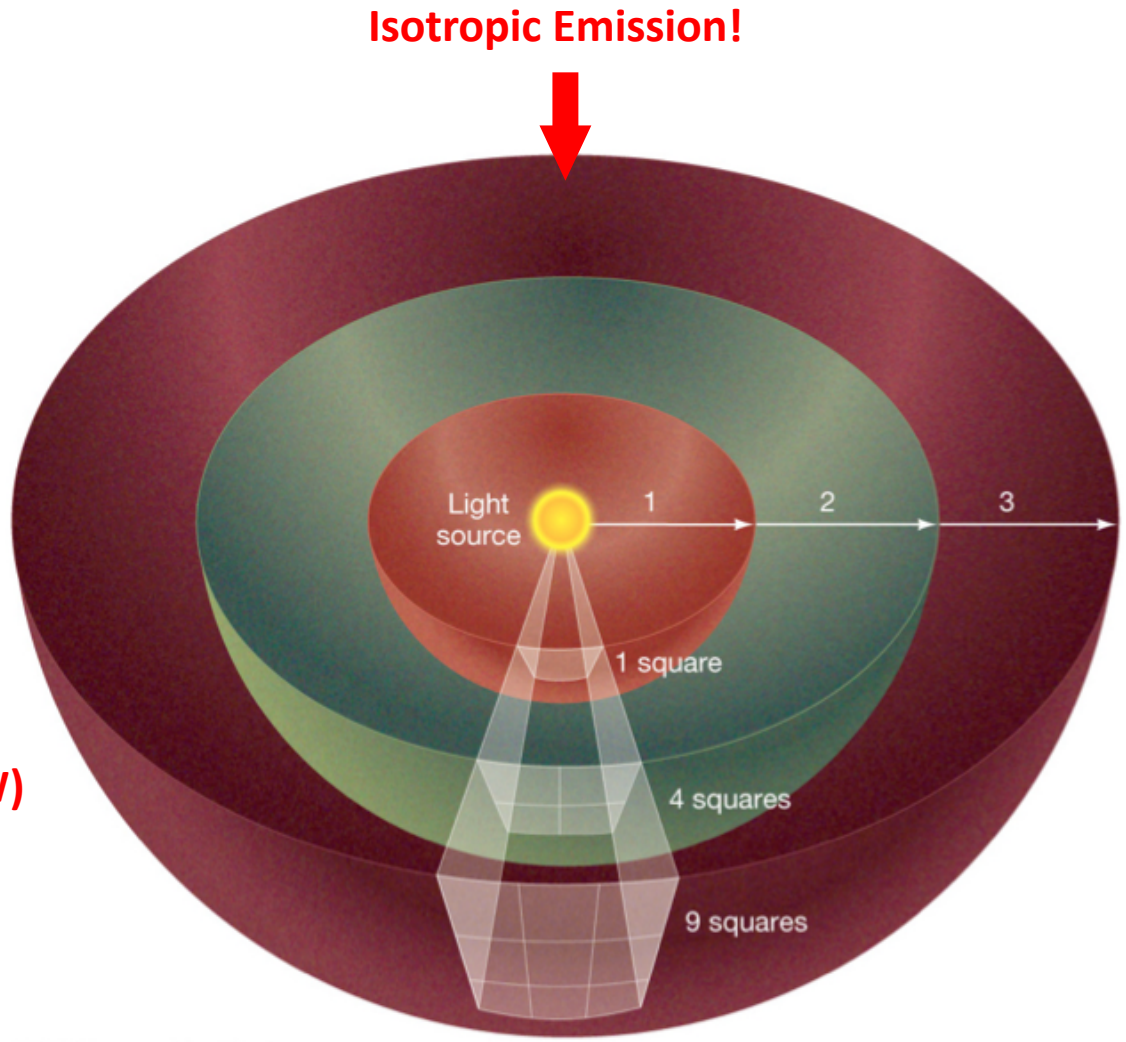
- This is known as **Flux**, F (W/m^2)
- Flux measures how the luminosity spreads out over a sphere for isotropic emission

$$F = \frac{L}{4\pi r^2}$$

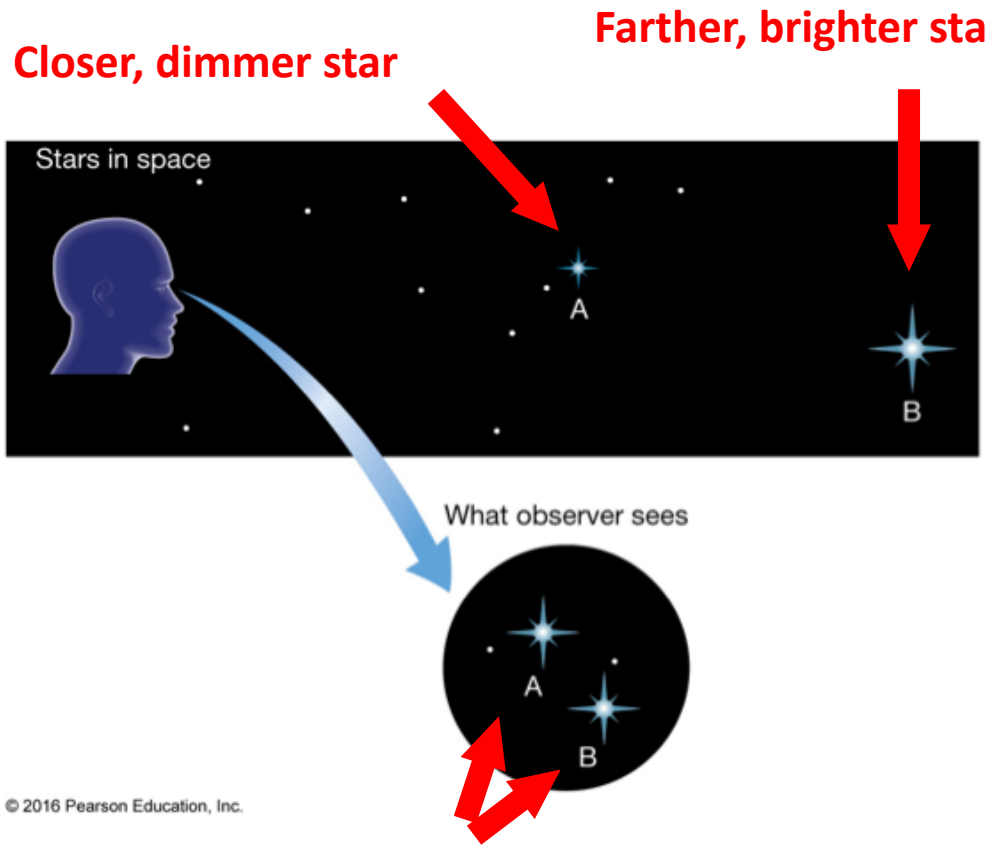
Luminosity (W)

Flux (W/m^2)

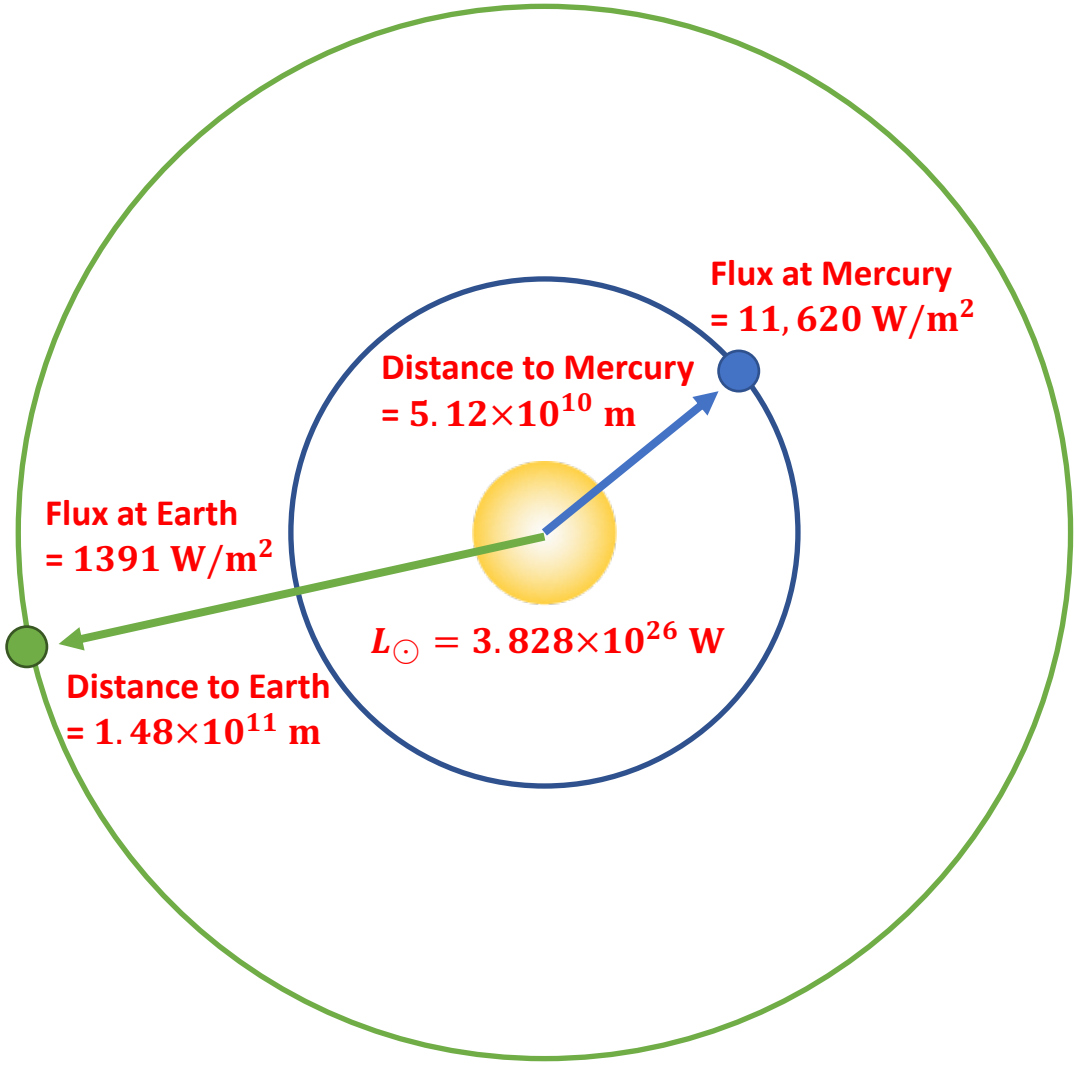
Surface area of sphere (m^2)



Flux and Distance



Both stars *appear* to be equally bright



Magnitude (of Brightness)

A common way to measure brightness is not in terms of luminosity or flux, but in terms of **magnitude** (of brightness)

- The **absolute magnitude (M)** replaces luminosity
- The **apparent magnitude (m)** replaces flux

Magnitude runs "in reverse" – the larger the magnitude, the dimmer the object is.

- 0 is the magnitude of Vega
- 6 is the dimmest object the human eye can see
- Negative magnitude are objects brighter than Vega
- The Sun is the brightest object in the sky at -26.7