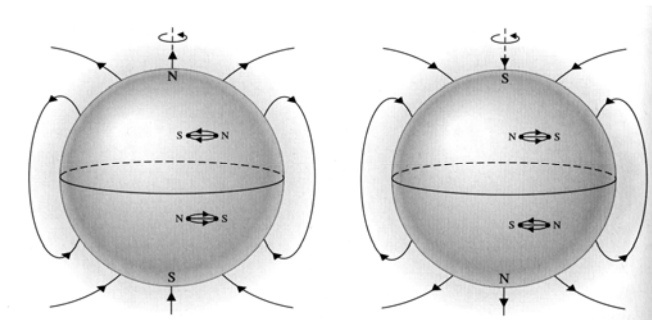
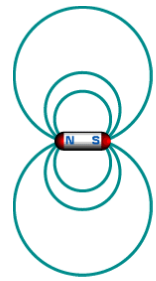
The Sunspot Cycle

- Caused by cyclical change in Sun’s magnetic field.
  - field reverses polarity each 11 years ➔ 22 year cycle.
  - reverses polarity of leading spots in pairs.

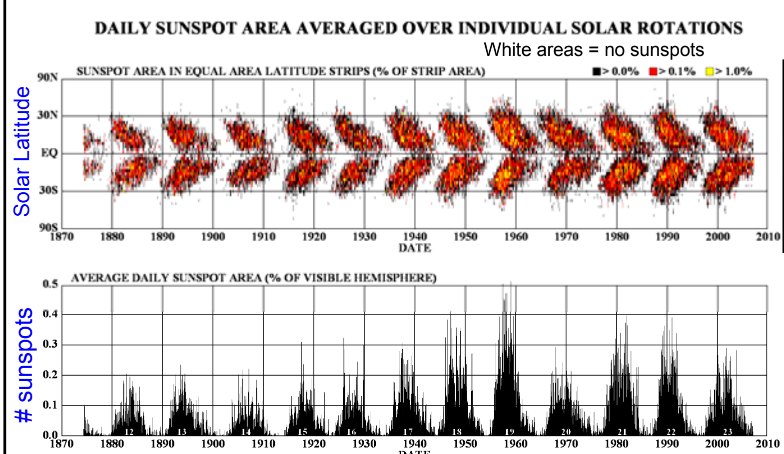


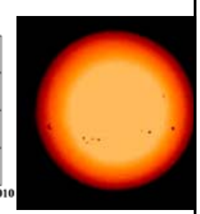
1st 11-year cycle   Next 11-year cycle



Magnetic field lines of force

- Sunspots are a detail showing how the Sun’s magnetic field is leaking out of the zones just below the Sun’s surface.
  - Magnetic field produced in outer 30% of Sun’s radius.





The Sunspot Cycle

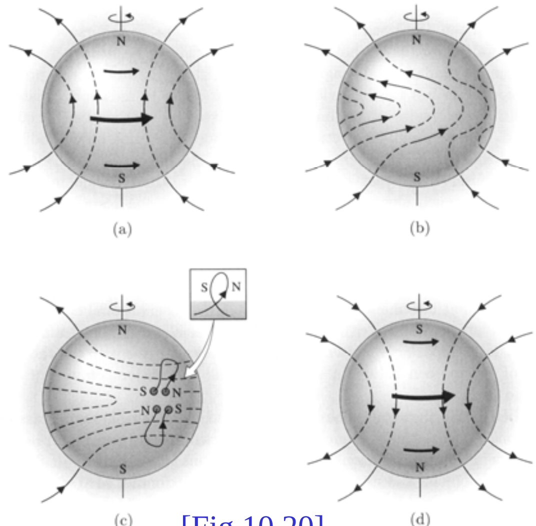
- 11 years between maxima.
  - Currently starting an upswing.

- A repeating cycle.
- Sunspots are formed far from equator at start.
- Later, form closer and closer to equator.

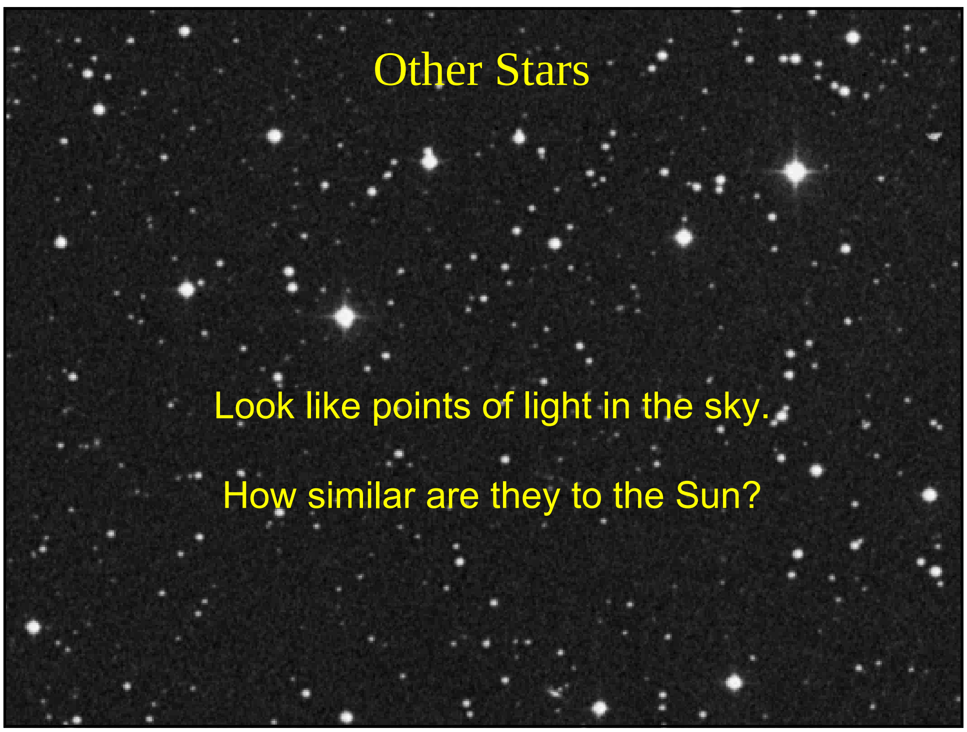
Solar activity: flares affect Earth.

What causes the solar cycle?

- Differential rotation of Sun's outer layers
  - 24 days at equator.
  - 30 days at pole.
  - reason not understood.
- "Winds up" magnetic field
  - field reverses each 11 yrs, when it gets too wound up.
  - causes 22-year cycle.
  - but why this reversal??? We don't know.



[Fig 10.20]



Other Stars

Look like points of light in the sky.

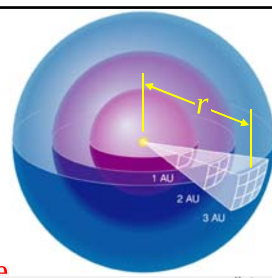
How similar are they to the Sun?

Other Stars

- Clicker question: *Which of the following things did we NOT need to know about the Sun in order to compute an accurate model of its interior?*

A. Chemical composition
B. Luminosity
C. Mass
D. Diameter
E. We needed to know all of the above

Finding the luminosity
[11.1]



[Fig. 11.2]

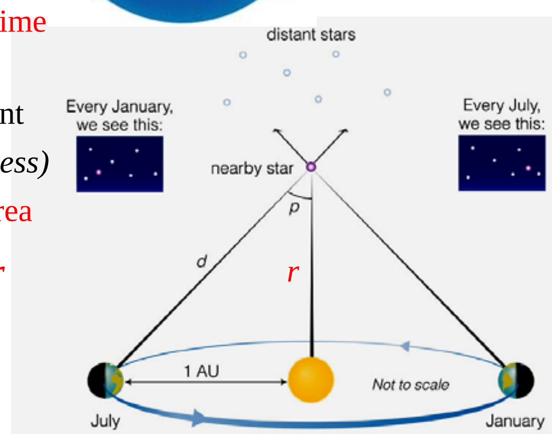
$$F = \frac{L}{4\pi r^2}$$

$$L = 4\pi r^2 F$$

- *Luminosity* = Energy/unit time
- But we measure *flux* incident on Earth *(apparent brightness)*
  = Energy/unit time /unit area

➔ Also must know distance r

- For nearby stars, use parallax:

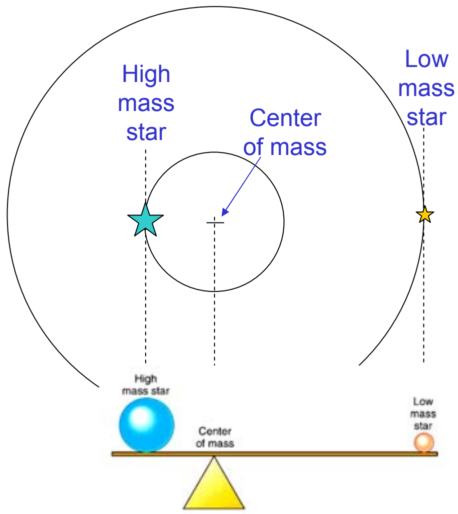


[Fig. 11.3]

Stellar masses

[11.1]

- Binary stars
- Use Newton's form of Kepler's 3rd law:



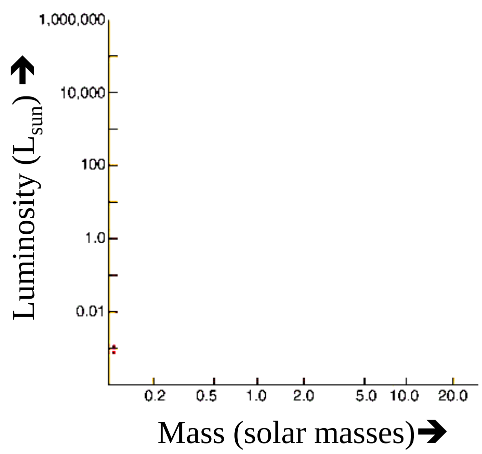
$$P^2 = \underbrace{\frac{4\pi^2}{G}}_{\text{constant}} \frac{a^3}{m_1 + m_2}$$

Orbits are about center of mass.

So can determine ratio m_1/m_2

Mass - Luminosity Relation

- Key observational result for theoretical interpretation of different types of stars.



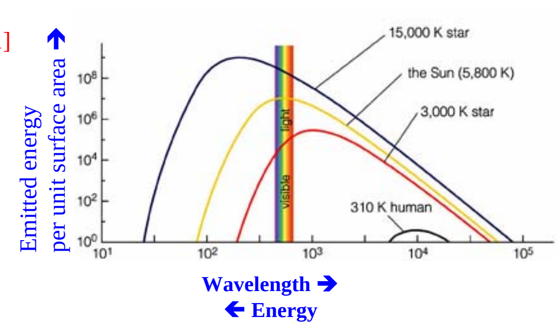
The Observed Properties of Stars

To compute an accurate model of the interior of a distant star, we need to know:

- ✓ A. Chemical composition
- ✓ B. Luminosity
- ✓ C. Mass
- D. Diameter

Finding the star's diameter

[Fig. 5.11]



- Total energy emitted *per unit surface area*

  Stefan-Boltzmann Law: $E = \sigma T^4$

- Total energy from whole star:

Surface area of sphere of diameter D

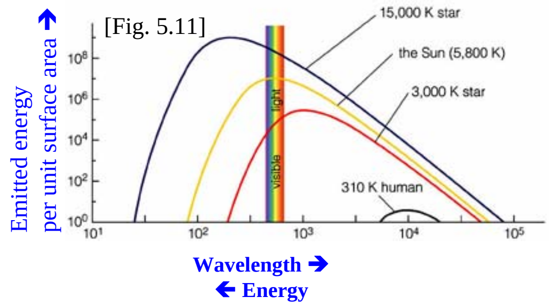
$$L = E \times (\text{surface area}) = (\sigma T^4) \times (\pi D^2)$$

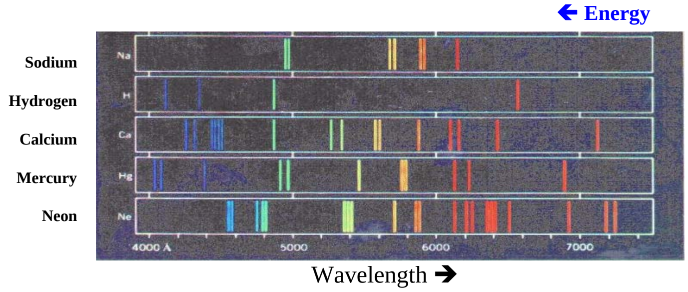
Luminosity

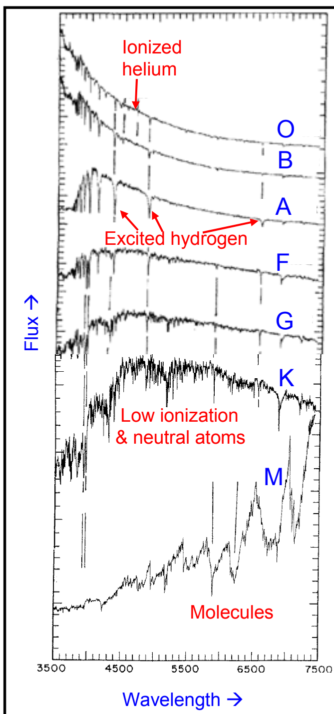
Taking a star's (surface) temperature

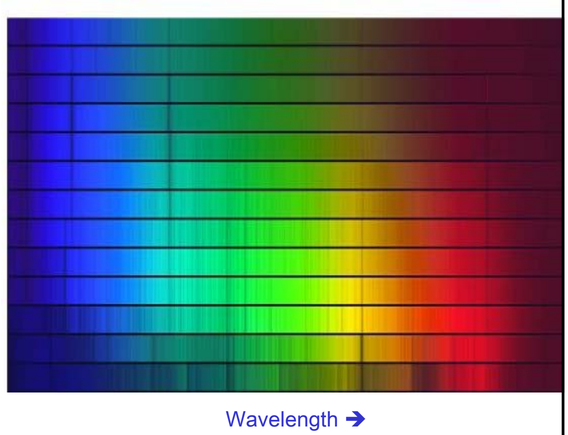
Two Ways:

- Thermal radiation curve
- Spectroscopy

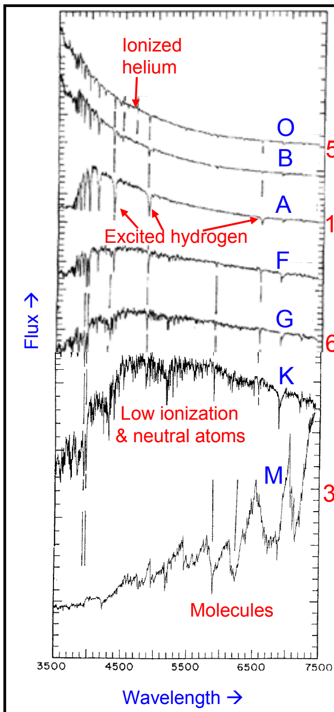








Spectra of different stars *look* different.



50,000° K

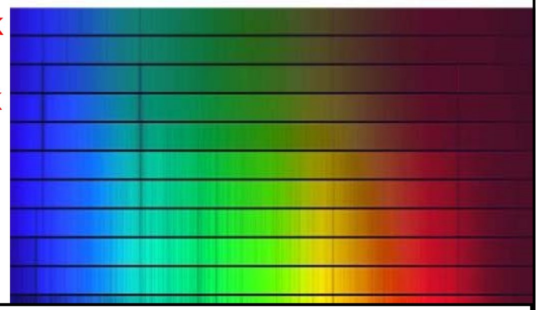
10,000° K

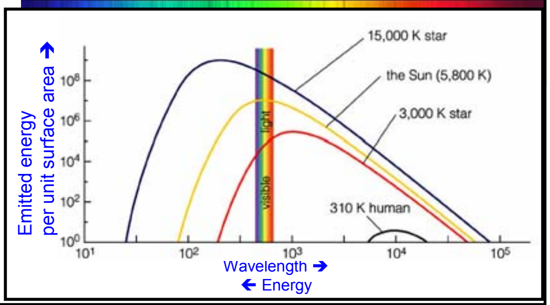
6,000° K

3,000° K

Due to the surface temperature!

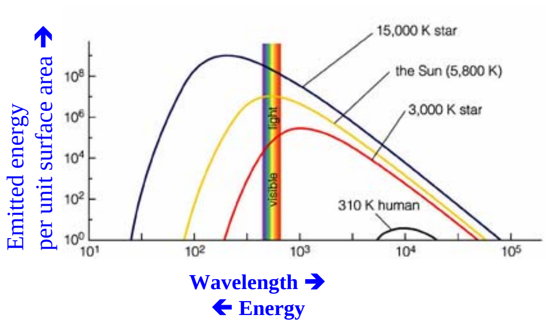
- Hot = blue color, abs. from high ionization states.
- Cool = red color, abs. lines from molecules.





Finding the star's diameter

[Fig. 5.11]



- Total energy emitted *per unit surface area*

  Stefan-Boltzmann Law: $E = \sigma T^4$

- Total energy from whole star:

Surface area of sphere of diameter D

$$L = E \times (\text{surface area}) = (\sigma T^4) \times (\pi D^2)$$

Luminosity

We measure L and T, then solve for D