Announcements

- Back to the grind: WebWorK due on Wednesday
- I should be able to hand tests back on Wednesday or Friday
- No lab this week!
  - If you have a lab to make-up, this is the week to do it!
  - Email me with what lab you want to be making up please!
- Poll: `rembold-class.ddns.net`

In the Sky

- Moon in waning gibbous
- Jupiter and Mercury hanging out together just after sunset
  - Should be able to see them both in the same field-of-view when using binoculars
- Saturn and Mars still up through much of the night
- Iridium Flare: Oct 30 at 6:00:36pm towards the West (mag=-7)
- ISS crossings:
  - Oct 30 at 7:07am (mag=-3.3)
  - Oct 31 at 6:17am (mag=-3.8)
- 0 sunspots on the Sun currently!

Review Question!

It takes energy thousands of years to travel from the interior of the Sun to Earth because:

A. The Earth is a really long way away
B. Neutrino's interfere with the gamma rays, slowing them down
C. Lots of collisions with charged particles slow and scatter the gamma rays
D. Neutrino's carry the bulk of the energy and travel much slower than light

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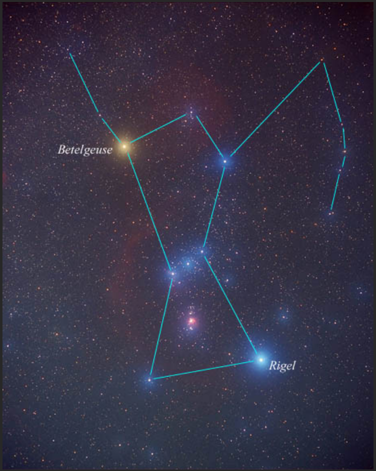
What can we directly observe?

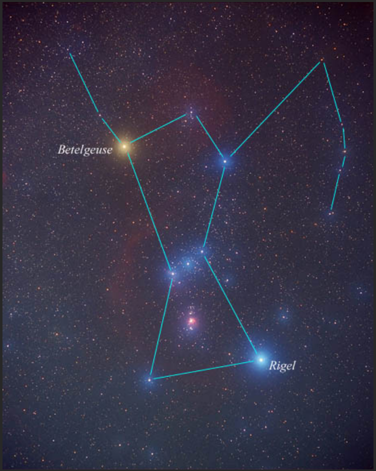
- The light from the stars tells us:
  - Their location in the sky
  - The intensity of their light
  - Their spectrum
- From these, we can determine:
  - Surface Temperature
  - Motion
  - Distance (sometimes)
  - Size (in a way)
  - Power output (Luminosity)
  - Mass (also sometimes)

A note on Angular Size

- Recall that the angular size of the Sun is about 0.5°
  - Angular sizes of stars much, much smaller
  - Generally smaller than can be resolved with any telescope
- Main exception: Betelgeuse
  - HST measured an angular size of 0.07 arcseconds
  - Equal to 20 millionth of a degree



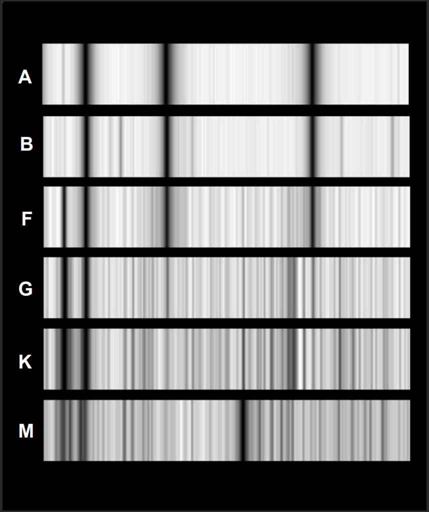
Truly Stellar Spectra!



- Stars come in a wide variety of colors
- These colors correspond to surface temperatures of $\approx 3000\,\mathrm{K}$ to $50\,000\,\mathrm{K}$
  - Wien's Law
  - Stefan-Boltzmann Law

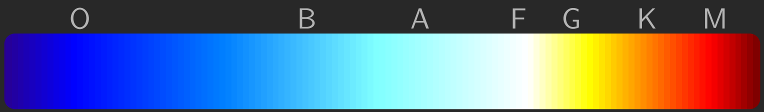
Just Not My Type

- Stars were originally classified by the strength of their Hydrogen lines
- The strongest were type A, all the way down to Type O



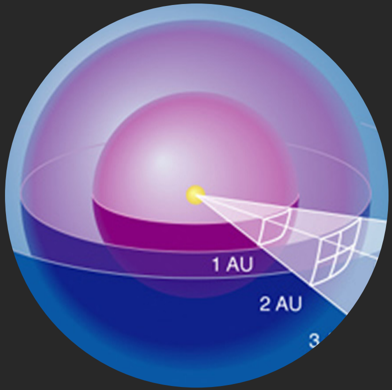
Scrambling the System

- As more star spectra observed, H lines were inadequate
- Annie Cannon
  - Classified some 350,000 stars (yeesh)
  - A new order based on Balmer lines, not alphabetical this time
  - Some classes overlapped and could be eliminated
- Mnenomics
  - Oh, Be A Fine Girl/Guy, Kiss Me
  - Only Boring Astronomers Find Gratification Knowing Mnemonics



It is Apparent!

- Apparent Brightness is the intensity of radiation from the star
  - As measured from the Earth's surface
  - Units of Watts/m^2
- For the Sun $B \approx 1400\,\mathrm{W/m^2}$
- This is much, much less for other stars
- The traditional unit of apparent brightness is apparent magnitude



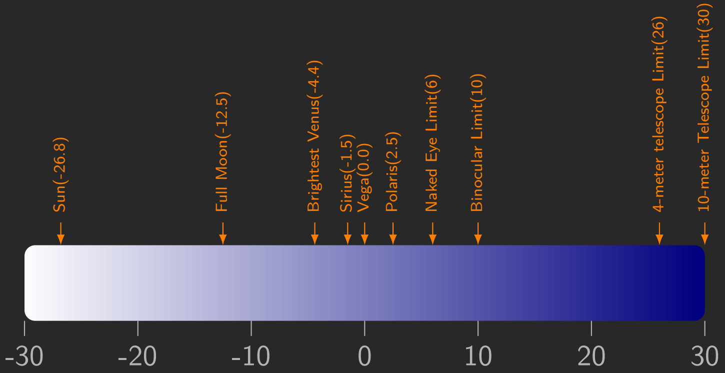
The Apparent Magnitude

- System introduced around 150 BC
- Hipparchus divided stars into six groups:
  - Brightest were “1st magnitude”
  - Faintest (that he could see) were “6th magnitude”
- These days we are much more precise:
  - 1st magnitude about 2.5 times brighter than 2nd
  - 2nd is about 2.5 times brighter than 3rd
  - Happens with a logarithmic scale!
    - A factor of 100 in brightness is a difference of 5 in magnitude

$$m = -2.5 \log \left(\frac{B_{obj}}{B_{Vega}} \right)$$

Making Sense of Magnitudes

- Smaller numbers mean brighter stars
- Numbers can be negative
- Smaller differences in magnitude correspond to larger differences in brightness



Magnitude Example

Example

I measure a nearby star to be 500 times brighter than the star Vega. What is the apparent magnitude of said star?

Flipping the Tables

- What if you want to go the other direction?
- Know two magnitudes and want to figure out how much brighter one object is than the other

$$\frac{B_1}{B_2} = 10^{0.4\times(m_2 - m_1)}$$

Reverse Example

Example

One of the Iridium Flares for tomorrow is to have an apparent magnitude of -7.0. How many times dimmer is this than the brightness of the full moon?

Luminosity

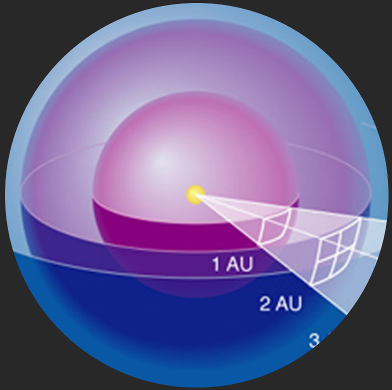
- We measure the apparent brightness B
- Brightness falls off with distance:

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

- Thus the luminosity is

$$L = 4\pi d^2 \times B$$

- Range of stellar luminosities is large:
  - $L_{Sun} = 4 \times 10^{26}$ W
  - Dimmest at $0.000001 L_{Sun}$
  - Brightest at $100000 L_{Sun}$



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