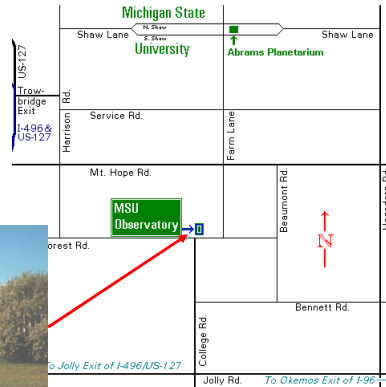


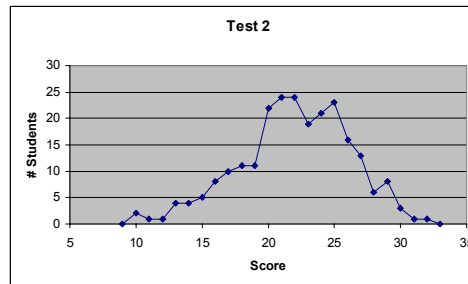
Hot-plate model of stars

- Public viewing sessions at MSU campus observatory.
 - Fri & Sat, 9-11pm, if it is not cloudy.
 - Mar 23 & 24
 - Apr 20 & 21
 - May 18 & 19
 - 24-inch telescope in dome
 - small telescopes outside
- Test 2 & grades



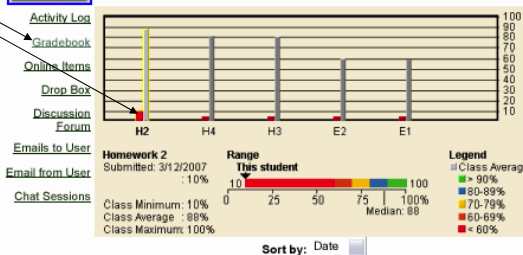
Test 2 & grades

- Test 2
 - Average 22/36
- Grades on Angel
 - Your grade
 - Tools>My Grades
 - Your grade & class distribution
 - Tools> Learning Profile
 - Select Gradebook
 - Click on assignment
 - Homework
 - Lowest dropped
 - Clicker
 - All included for now
 - Lowest 10% & excused absences will be dropped.
 - More than 50% of grade remains.



E-Learning Monitoring and Assessment
agent version 2.0

NAME: Edwin D Loh
Email: joh@msu.edu



Hot-plate model of stars

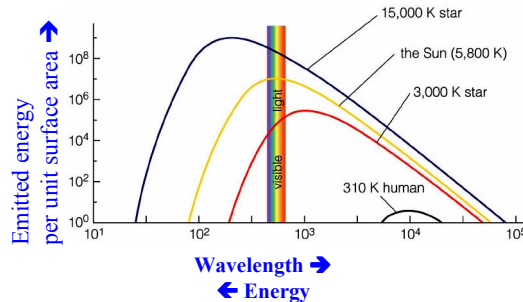
- Q1 What quantities determine to a great extent the total amount of light that stars, the sun, a hot plate, and I emit?
 - Composition
 - Temperature
 - Size
 - a. C & T
 - b. T & S
 - c. S & C
 - d. All 3



Orion constellation
<http://lithops.as.arizona.edu/~jill/EPO/Posters/Orion/protoplanets.html>

Hot-plate Model of a Star

- A hot plate emits light as a blackbody. The key parameters are
 - Temperature
 - Area
- A star is a really hot and really big hot plate.
- Ingredients
 - Radius: R . Area = $4\pi R^2$
 - Temperature: T
 - Distance: D
- Goal is to discover the model for flux, the amount of energy we on Earth receive per second per area of telescope.
- Reasoning process:
 - If the temperature is hotter, the flux is ____ (greater or less).
- Q2: Should T , D , & R be in the numerator or denominator?
 - a. NNN
 - b. NND
 - c. NDN
 - d. DNN



Hot-plate Model of a Star

- A hot plate emits light as a blackbody. The key parameters are

- Temperature
- Area

- A star is a really hot and really big hot plate.

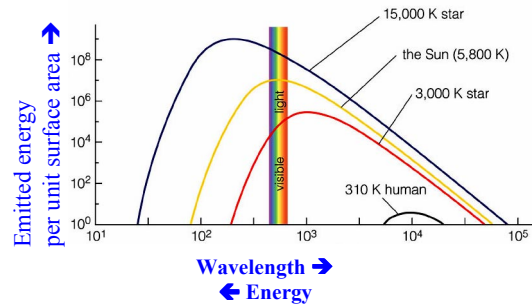
- Ingredients

- Radius: R . Area = $4\pi R^2$
- Temperature: T
- Distance: D

- Hot plate model for flux

$$F = R^2 T^4 / D^2$$

$$\text{Flux} = \text{Radius}^2 \text{Temp}^4 / \text{Dist}^2$$



- Q2: Should T , D , & R be in the numerator or denominator?

- NNN
- NND
- NDN
- DNN

Hot-plate Model of a Star

- A Hot plate model for flux

$$F = R^2 T^4 / D^2$$

$$\text{Flux} = \text{Radius}^2 \text{Temp}^4 / \text{Dist}^2$$

- We measure **flux** incident on detector on Earth

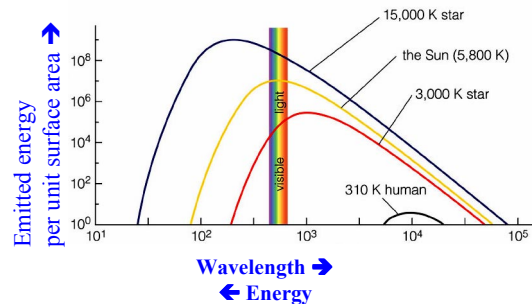
- Energy/unit time /unit area

- Luminosity** is a quantity intrinsic to the star

- Energy/unit time
- Independent of distance to earth.

$$L = R^2 T^4$$

- To find luminosity of a star, we need to measure its distance. (This is difficult.)

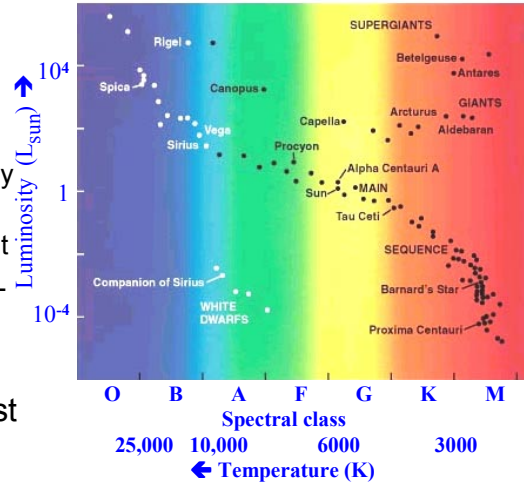


- Q3: A giant hand moved Betelgeuse closer. Its flux and luminosity would be ___?

- Bigger & bigger
- Bigger & same
- Same & same

Hertzsprung-Russell (H-R) Diagram

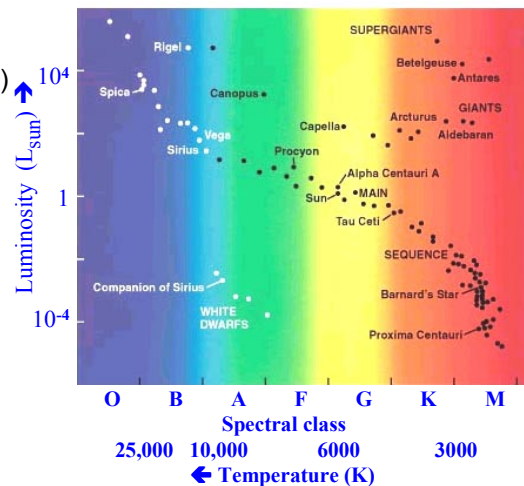
- H-R plotted luminosity vs. surface temperature (1905)
 - Spectral class is a proxy for temperature
 - OBAFGKM. O is hottest
- Stars: A-Aldebaran; B-Barnard's Star; C-Capella; D-Rigel
- Q4 Which is the hottest star?



[see Fig. 11.10]

Hertzsprung-Russell (H-R) Diagram

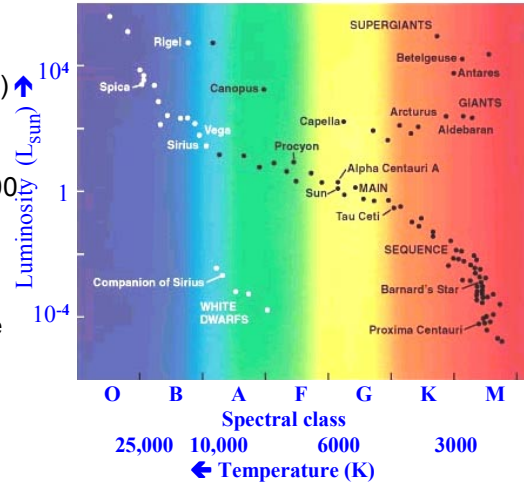
- H-R plotted luminosity vs. surface temperature (1905) & discovered a surprise.
 - Spectral class is a proxy for temperature
 - OBAFGKM. O is hottest
- Q4 Sirius A & Sirius B (companion of Sirius A) have about the same temperature. How can Sirius B be 10,000 times fainter?
 - a. Sirius B is 100 times farther away.
 - b. Sirius B is 100 times smaller
 - c. Sirius A took away the mass
 - d. Sirius A took away the light



[see Fig. 11.10]

Hertzsprung-Russell (H-R) Diagram

- H-R plotted luminosity vs. surface temperature (1905) & discovered a surprise.
- Sirius A is slightly larger than the sun. Sirius B is 100 times smaller. The same size as the Earth!
- Stars come in 3 sizes.
 - Main sequence: about the size of sun
 - White dwarf: size of Earth
 - Giants

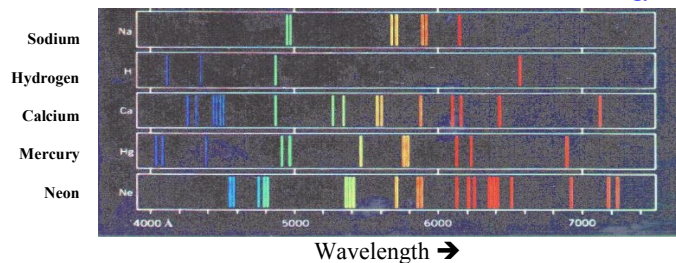
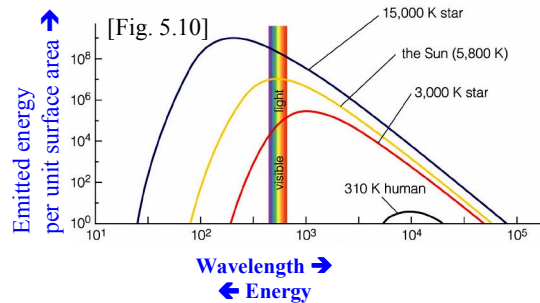


[see Fig. 11.10]

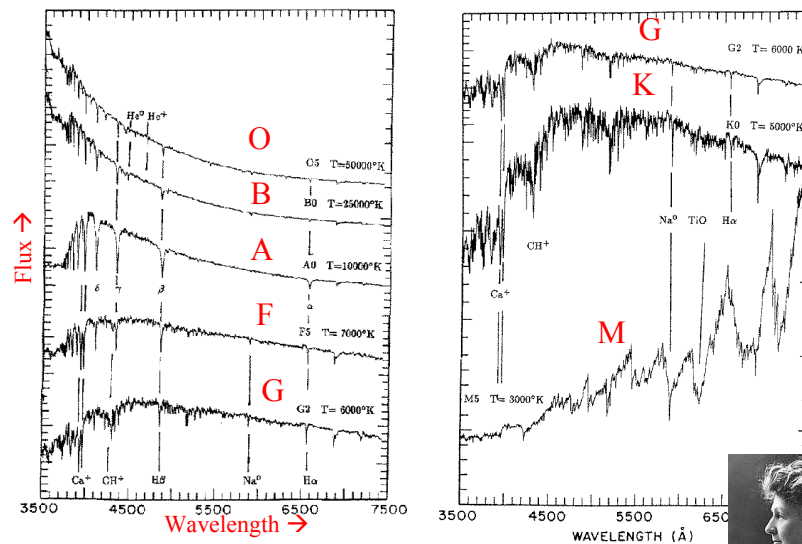
Taking a star's temperature

Two Ways:

- Compare amount of light in two colors
 - Blackbody curve
- Spectroscopy



Annie Jump Cannon: Classify stars by spectra



Very efficient: Draper catalog has 250,000 stars

AJC 1863-1941

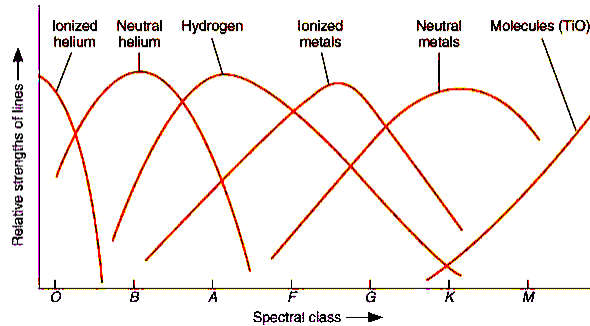


- Prof. Pickering's Team in 1913, from Barbara L. Welther, 1982, Isis 73, 94.
- AJC
 - BA, Wellesley, 1884
 - Pickering's assistant, 1896
 - Henry Draper catalog of stars, 1918-1924
 - Astronomer 1938



Stellar spectral types

• A Temperature Sequence



Type	Temperature
O	>30,000
B	10,000-30,000
A	7500-10,000
F	6000-7500
G	5000-6000
K	3500-5000
M	<3500

in K

Extra-Credit for best OBAFGKM mnemonic.

- 3 clicker points for entering.
- 3 clicker points for 10 best answers that can be repeated in class.
- Enter in Angel before 31 March.

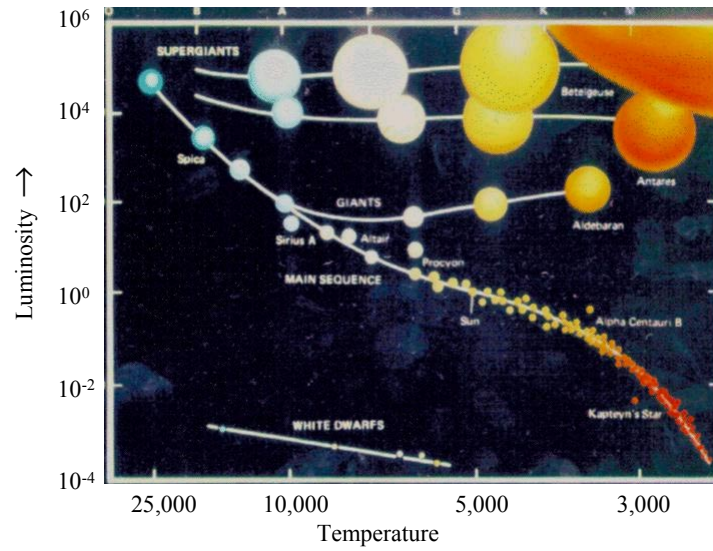
Observed properties of stars

- Mass
 - Measured in kg or M_{\odot}
 - 0.08-30 M_{\odot}
- Surface temperature
 - 5800K for sun
 - 3000 K for cool star
- Luminosity is amount of energy the star produces in a second
 - Watts=Joules/s or L_{\odot}
 - 40,000 L_{\odot} for Betelgeuse
- Flux or apparent brightness is amount of energy received from the star by a detector in a second.
 - Depends on distance
- Composition: abundances of elements.

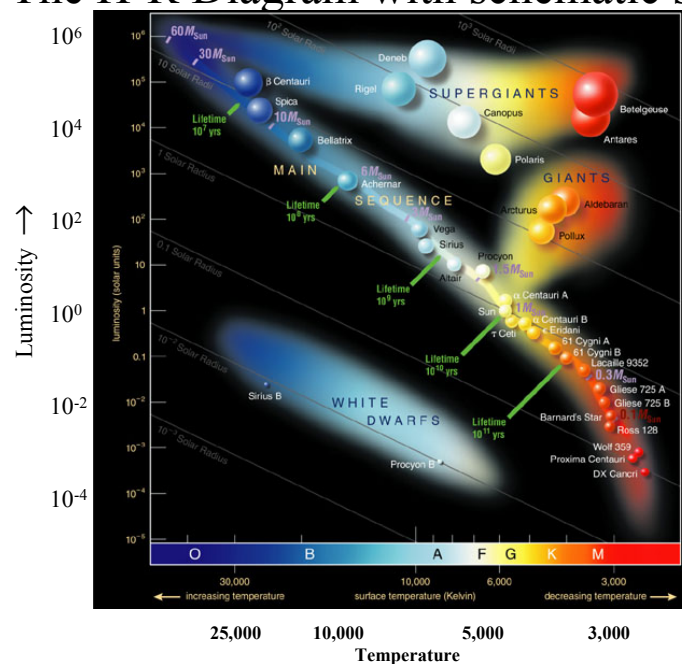


Orion constellation
<http://lithops.as.arizona.edu/~jill/EPO/Posters/Orion/protoplanets.html>

The H-R Diagram with sizes



The H-R Diagram with schematic sizes



[Fig. 11.10]

Mass determines location on main sequence

