Lecture 31

The Properties of Stars

Astronomy 141 – Winter 2012

This lecture describes the basic observed properties of stars.

The color of a star depends on its temperature: cooler stars are redder, hotter stars are blue.

Luminosity, the total energy output expressed in Watts or Solar Luminosities, depends on the radius and temperature.

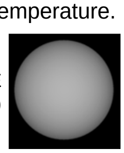
The absorption spectra of stars form a distinct sequence with stellar temperature, giving us a way to classify stars.

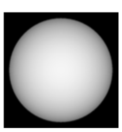
Spectral Classes of Stars: O B A F G K M L T

The Hertzsprung-Russell (HR) Diagram plots luminosity vs. temperature, dividing stars into main-sequence and giants.

Stars are hot, dense balls of gas that are approximately black bodies of a single temperature.

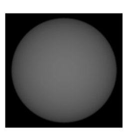
Hotter stars appear BLUE (T=10,000-50,000K)





Medium-Hot stars appear YELLOW (T~6000K)

Cool stars appear RED (T~3000K)



Colors of stars are hard to see with the naked eye; binoculars help, & big telescopes help more.

The Luminosity, L, of a star is a measure of its total energy output.

Measured in Watts – Joules/sec, or in units of the [present-day] Luminosity of the Sun:

$$1\ L_{sun} = 3.486\times10^{26}\ \text{Watts}$$

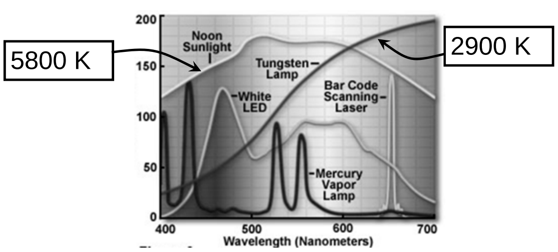
Large range of stellar luminosities from 10^{-4} to $10^{6}\ L_{sun}$

What we *observe*, however, is apparent brightness, B:

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

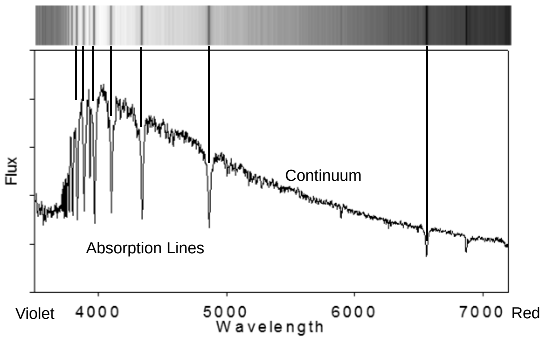
We must know the *distance* to the star to estimate L.

How can you accurately determine the surface temperature of a star?



Look at its spectrum = flux as a function of the wavelength of light.

The spectrum of stars consists of absorption-lines superimposed on a continuum spectrum



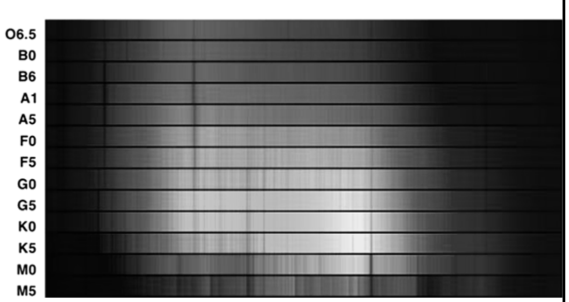
In 1901, Annie Jump Cannon noticed that the spectrum of a star depended on its Temperature.

Re-ordered an earlier A-B-C spectral classification scheme by stellar temperature, throwing out redundant types.

O B A F G K M

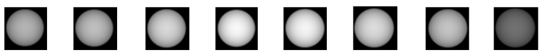
Later work added the very cool L-type stars...

Stellar Spectral Sequence



O stars are hottest, M stars are coolest.

The Spectral Sequence is a temperature sequence, from the hottest (O) to the coolest (L)



O B A F G K M L

Hottest 50,000K ← Coolest 1300K

Bluest → Reddest

What spectrum you measure depends primarily on the state of *excitation* and *ionization* of the gas, not so much composition.

Summary of Stellar Properties

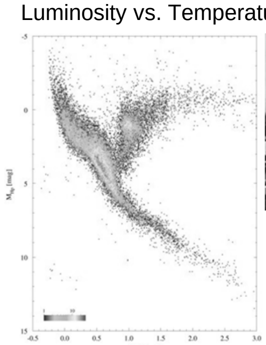
Large range of Stellar Luminosities:
10^{-4} to 10^{6} L_{sun}

Modest range of Stellar Temperatures:
2000 to >50,000 K

Large range of Stellar Radii:
10^{-2} to 10^{3} R_{sun}

Wide Range of Stellar Masses:
0.08 to ~50 M_{sun} (with rare stars up to few 100 M_{sun})

The Hertzsprung-Russell (H-R) Diagram plots the Luminosity vs. Temperature of stars.



Eljnar Hertzsprung

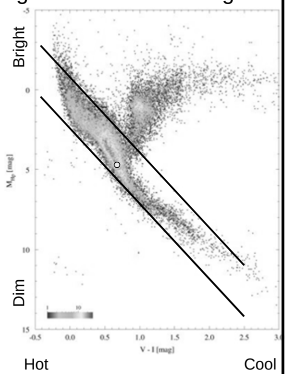
Henry Norris Russell

Key to understanding the physics of the stars.

The Main Sequence is a diagonal band containing 85% of nearby stars.

Range of properties:
- $L = 0.01$ to $10^6\ L_{sun}$
- $T = 2000$ to $>50{,}000$ K
- $R = 0.1$ to $10\ R_{sun}$

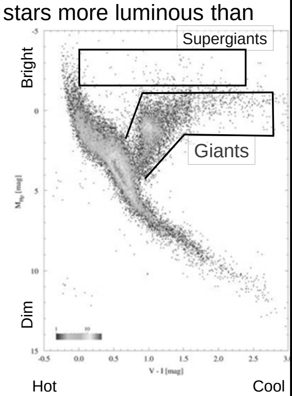
The Sun is a Main Sequence Star



Giants & Supergiants are stars more luminous than Main Sequence stars of the same temperature.

Giants:
- $R = 10 - 100\ R_{sun}$
- $L = 10^3 - 10^5\ L_{sun}$

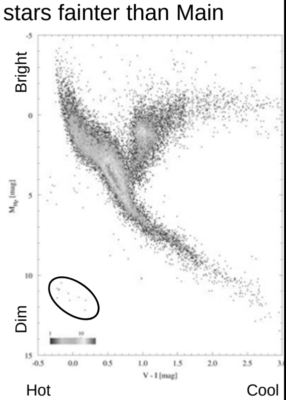
Supergiants:
- $R > 1000\ R_{sun}$
- $L = 10^5 - 10^6\ L_{sun}$



White Dwarfs are tiny, hot stars fainter than Main Sequence Stars of the same temperature.

To be so dim, despite being white-hot, they must be tiny.

A typical white dwarf is only as big as the Earth!



Sun: G, main sequence

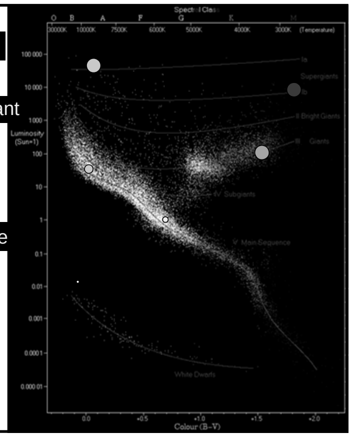
Betelgeuse: M, supergiant

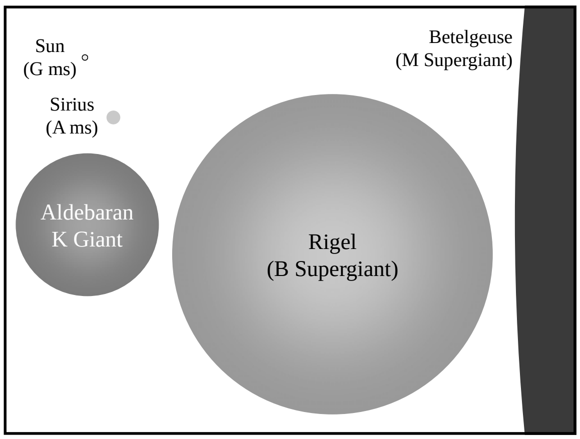
Rigel: B, supergiant

Sirius: A, main sequence

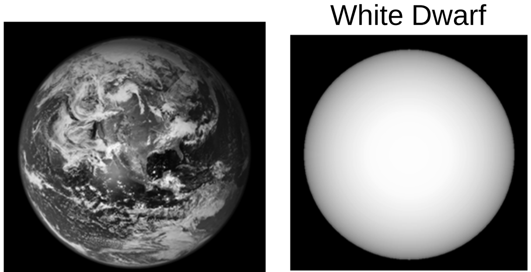
Aldebaran: K, giant

Sirius B: white dwarf





Sirius B
White Dwarf



$M \approx 1.0\ M_{sun}$
$R \approx 5800$ km