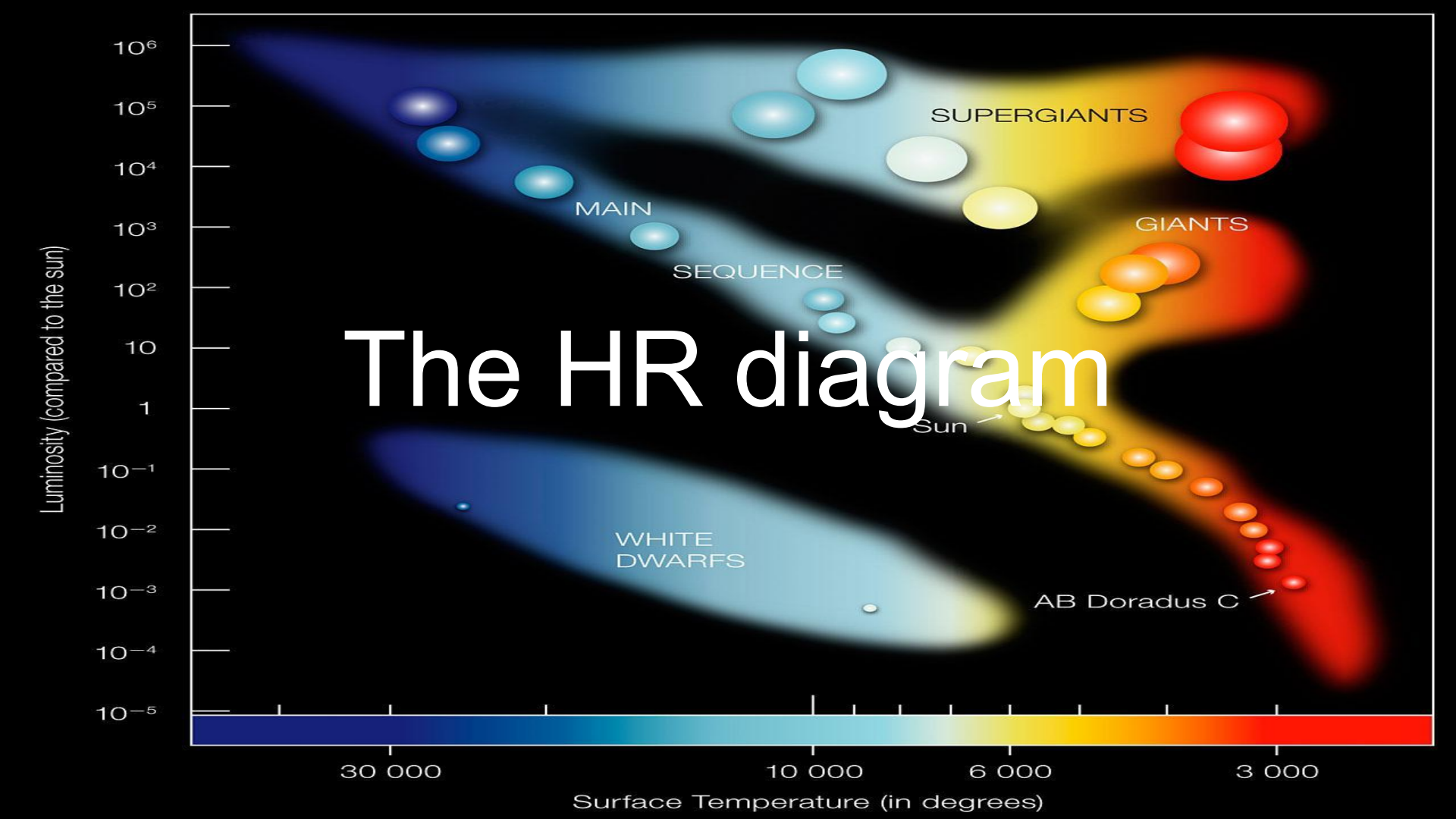

The HR diagram
Luminosity (compared to the sun)
10^{6}
10^{5}
10^{4}
10^{3}
10^{2}
10
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
SUPERGIANTS
MAIN
SEQUENCE
GIANTS
Sun
WHITE
DWARFS
AB Doradus C
30 000
10 000
6 000
3 000
Surface Temperature (in degrees)

Outline

- Poll everywhere question
- Solar telescope
- Working with apparent magnitudes (subtraction)
- Absolute magnitude
- Distance modulus
- HR diagram
- Main sequence
- Supergiants
- White dwarfs

Poll everywhere

When poll is active respond at **PollEv.com/nikhilpatten355**

Send **nikhilpatten355** to **22333**

Poll everywhere

results

Solar telescope

Apparent magnitudes

- Apparent magnitudes are a measure of flux (brightness)
- Allow us to easily compare relative brightness
- Subtracting magnitudes gives ratio of fluxes

$$m = -2.5 \log \frac{F}{F_0}$$

$$m_2 - m_1 = -2.5 \log \frac{F_2}{F_0} - \left(-2.5 \log \frac{F_1}{F_0} \right)$$

$$m_2 - m_1 = -2.5 \log \frac{F_2}{F_0} + 2.5 \log \frac{F_1}{F_0}$$

$$m_2 - m_1 = -2.5 \log \frac{F_2}{F_1}$$

Apparent magnitudes

$$m_2 - m_1 = -2.5 \log \frac{F_2}{F_1}$$

$$F \propto \frac{1}{d^2}$$

$$\boxed{m_2 - m_1 = -5 \log \frac{d_1}{d_2}}$$

Apparent magnitudes

1. Albiero is a binary star system in Cygnus. Albireo Aa has apparent magnitude 3.21 and Albireo B has apparent magnitude 5.11. How many times brighter is Albireo Aa than Albireo B?

a. 5.75 b. 2.16 c. 8.23

Apparent magnitudes

1. Albiero is a binary star system in Cygnus. Albireo Aa has apparent magnitude 3.21 and Albireo B has apparent magnitude 5.11. How many times brighter is Albireo Aa than Albireo B?

a. **5.75** b. 2.16 c. 8.23

Absolute magnitudes

- Magnitude is a measure of stellar flux (brightness)
- Flux is dependent on distance
- Astronomers often express luminosity in “absolute magnitude”
- The apparent magnitude of a stars as seen from 10 parsecs
- If most stars’ apparent magnitudes are larger than absolute, what does this tell us?

Star	Apparent Magnitude m	Absolute Magnitude M
The Sun	-26.93	4.8
Sirius	-1.44	1.41
Vega	0.03	0.58
Betelgeus	0.45	-5.14
GJ 75	5.63	5.63

Distance modulus

- Absolute magnitude is independent of distance
- Apparent magnitude isn't
- Given both apparent and absolute magnitudes, we can find distance
- Distance modulus
- Larger distance modulus → further away

$$\mu = m - M$$

$$\mu = 5 \log d \ (\mathrm{pc}) - 5$$

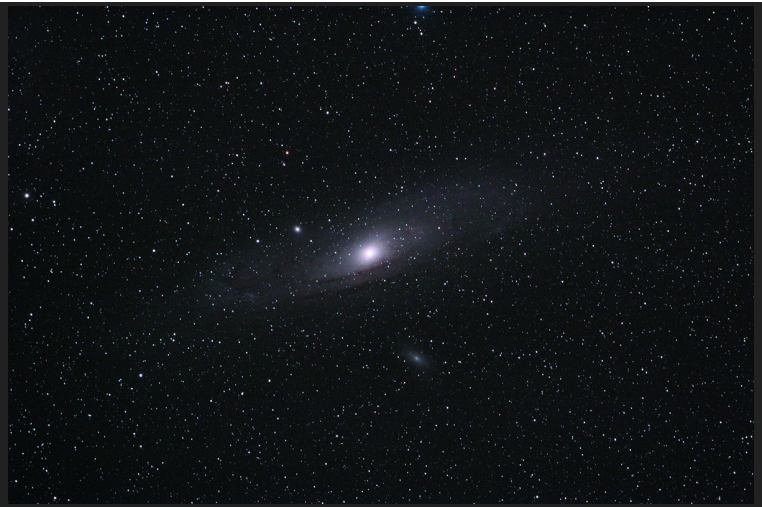
Distance modulus

2. The Andromeda galaxy has apparent magnitude +3.4 and Absolute magnitude -21.5. How far away is it?

$$\mu = m - M$$

$$\mu = 5 \log d \ (\mathrm{pc}) - 5$$

a. 457,000 pc b. 955,000 pc
c. 857,000 pc d. ???



Distance modulus

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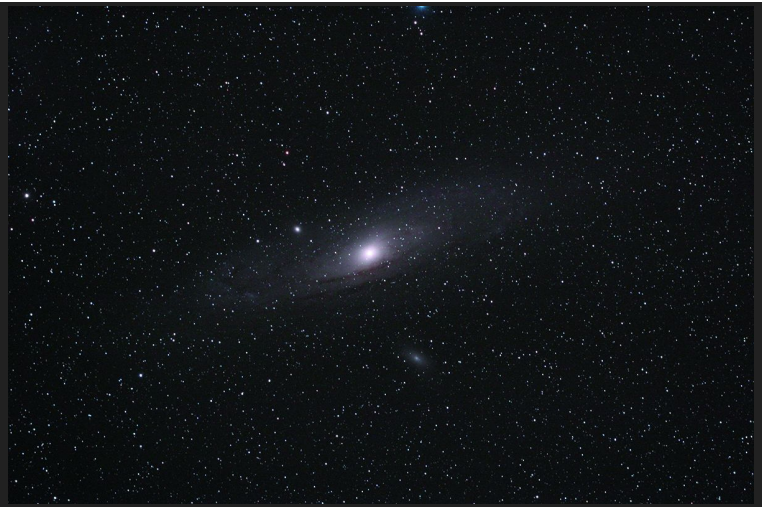
$$\mu = m - M$$

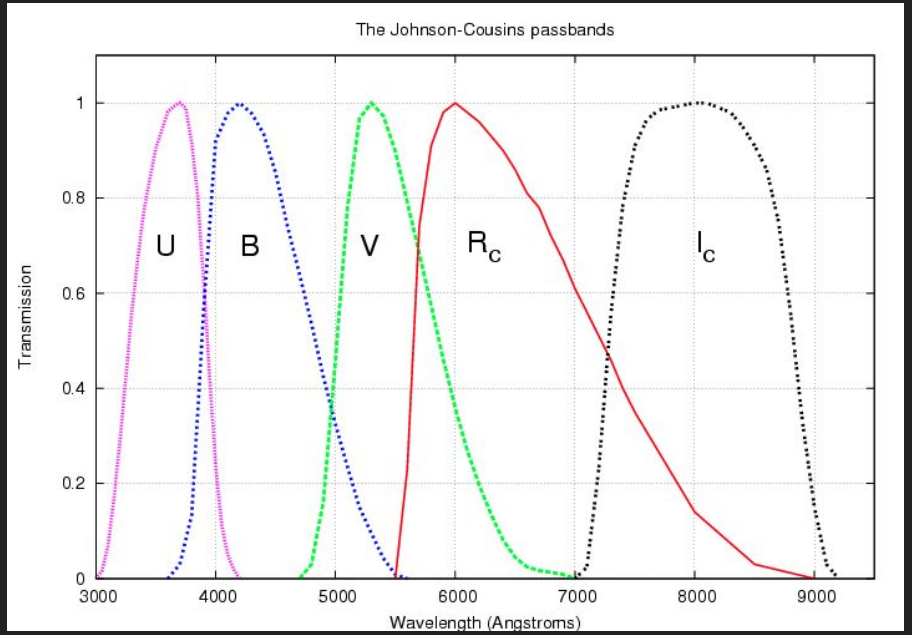
$$\mu = 5 \log d \ (\mathrm{pc}) - 5$$

a. 457,000 pc b. **955,000 pc**
c. 857,000 pc d. ???



Color

- Astronomers measure stellar brightness in different filters
- Astronomers define color by difference in magnitudes in different filters
- Color = Blue filter -Red filter
- Hotter stars are (usually) bluer than cooler stars



Color

3. Betelgeuse and Bellatrix are stars in the constellation Orion. Which star is brighter in V? Which star has bluer V-R?

Betelgeuse

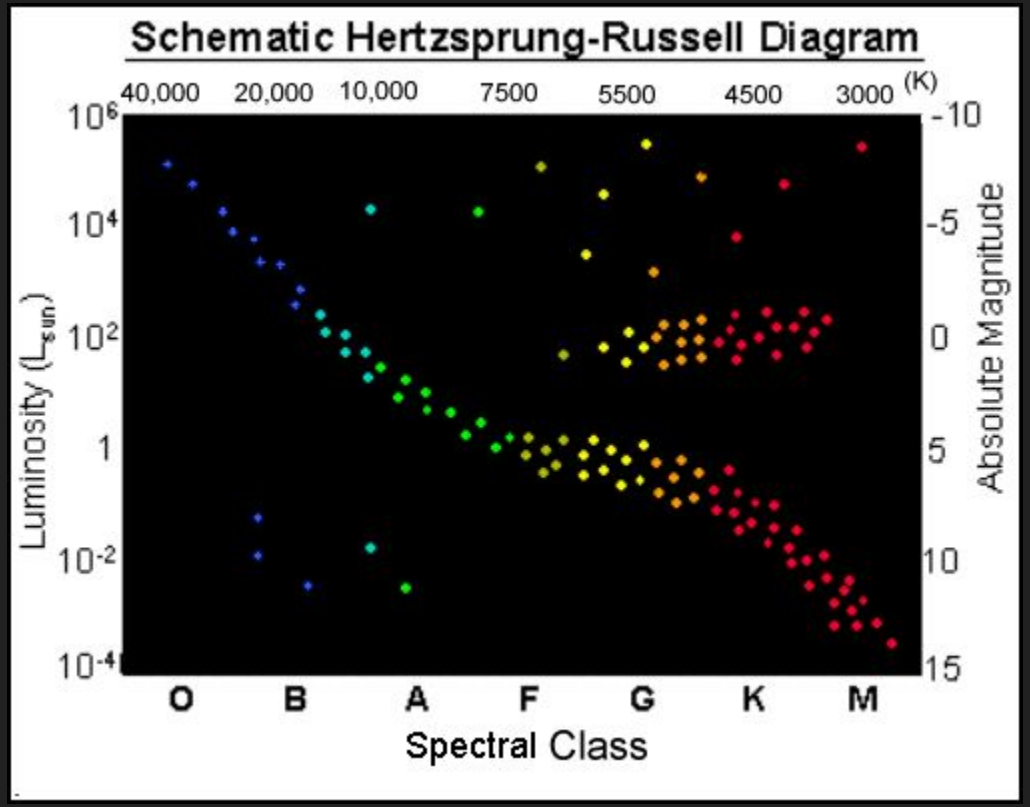
Bellatrix

Star	U	B	V	R
Betelgeuse	4.38	2.27	0.42	-1.17
Bellatrix	0.54	1.42	1.64	1.73

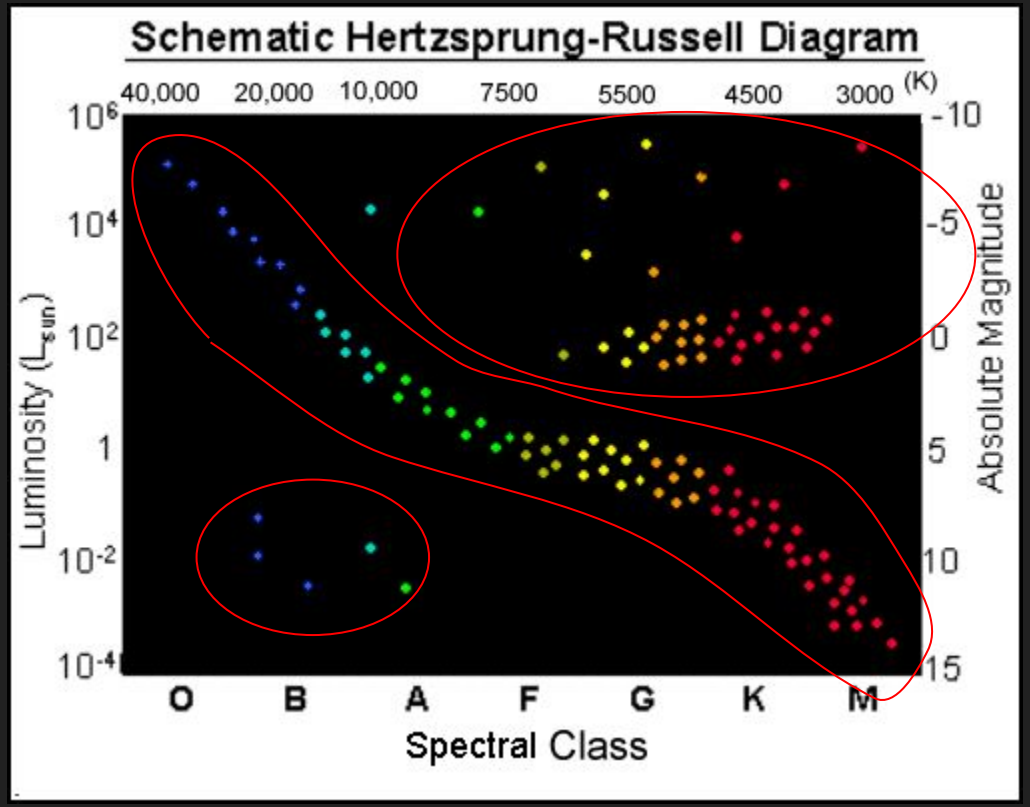
HR diagram

- Absolute magnitude is a measure of luminosity
- Color index is a measure of temperature
- What happens when we compare many stars absolute magnitude and color?

HR diagram


Schematic Hertzsprung-Russell Diagram
40,000
20,000
10,000
7500
5500
4500
3000
(K)
10^6
10^4
10^2
1
10^{-2}
10^{-4}
Luminosity (L_{sun})
-10
-5
0
5
10
15
Absolute Magnitude
O
B
A
F
G
K
M
Spectral Class

HR diagram


Schematic Hertzsprung-Russell Diagram
40,000
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O
B
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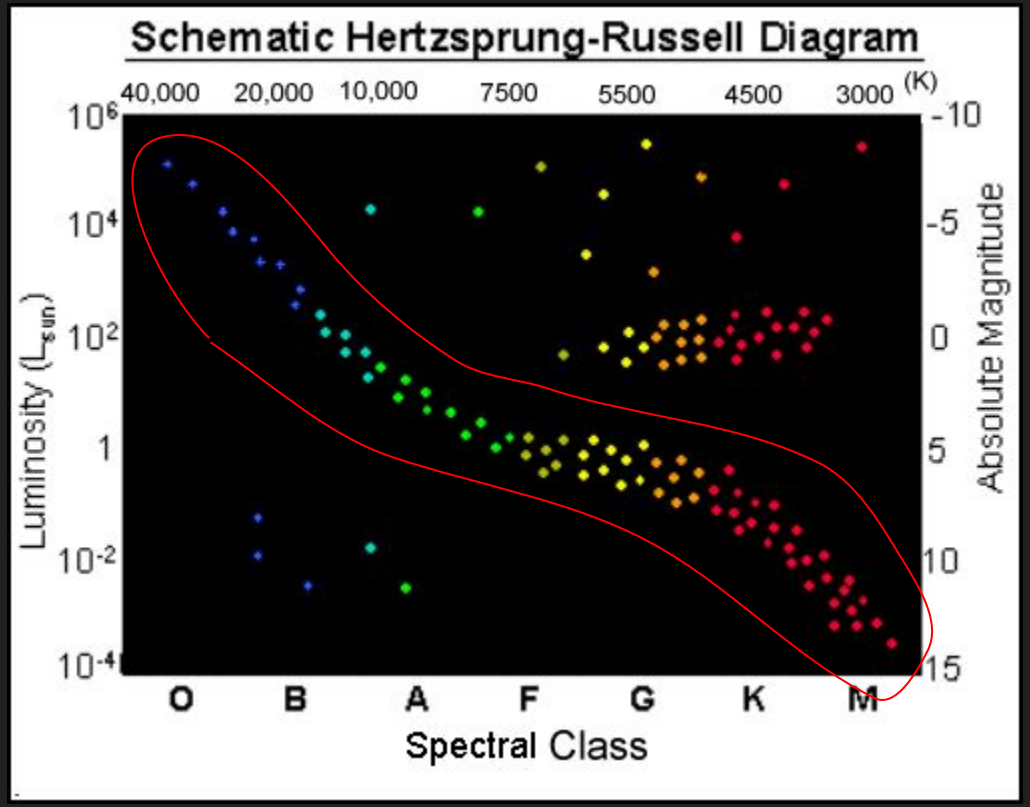
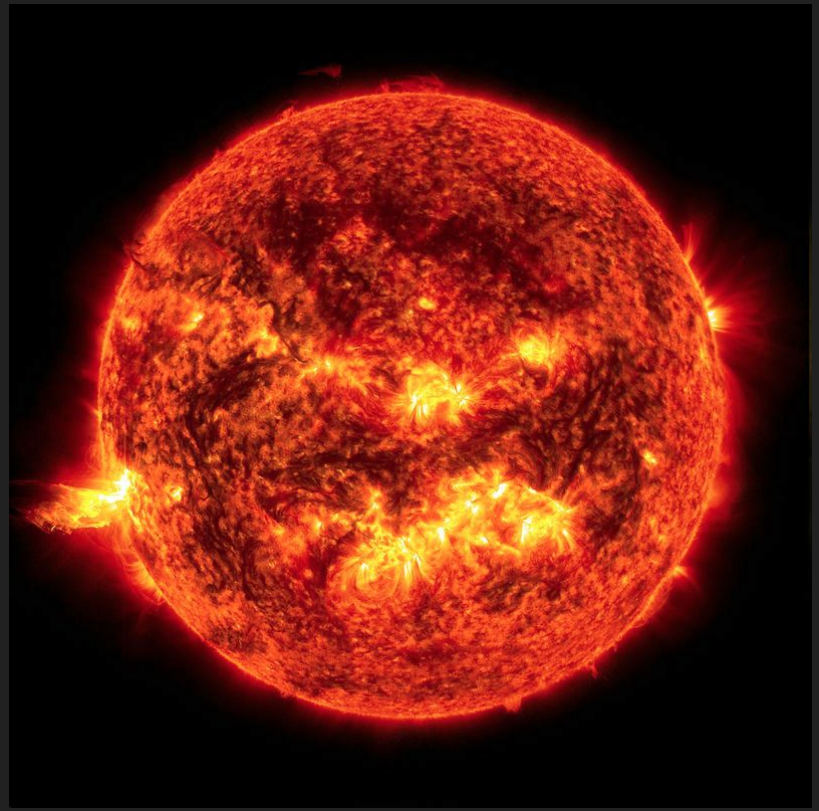
The main sequence



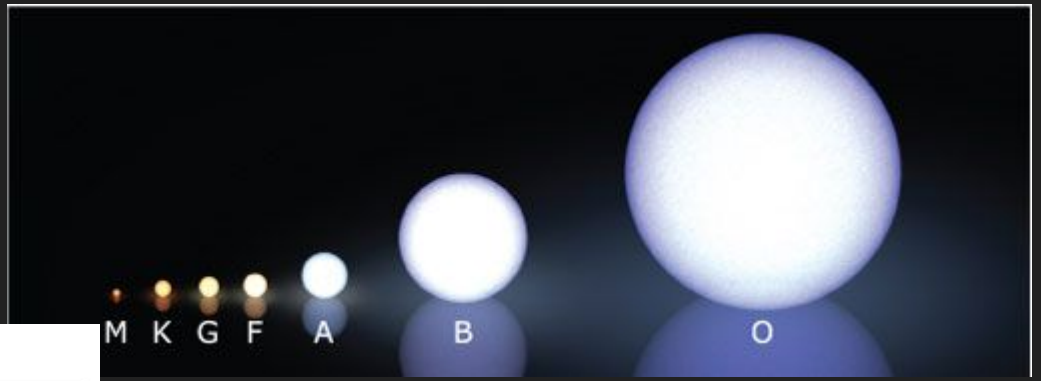
The main sequence

- Stars spend the majority of their lives fusing hydrogen into helium in their cores
- This is the main sequence



The main sequence

- Some main sequence stars are hotter than others
- Temperature is determined by mass

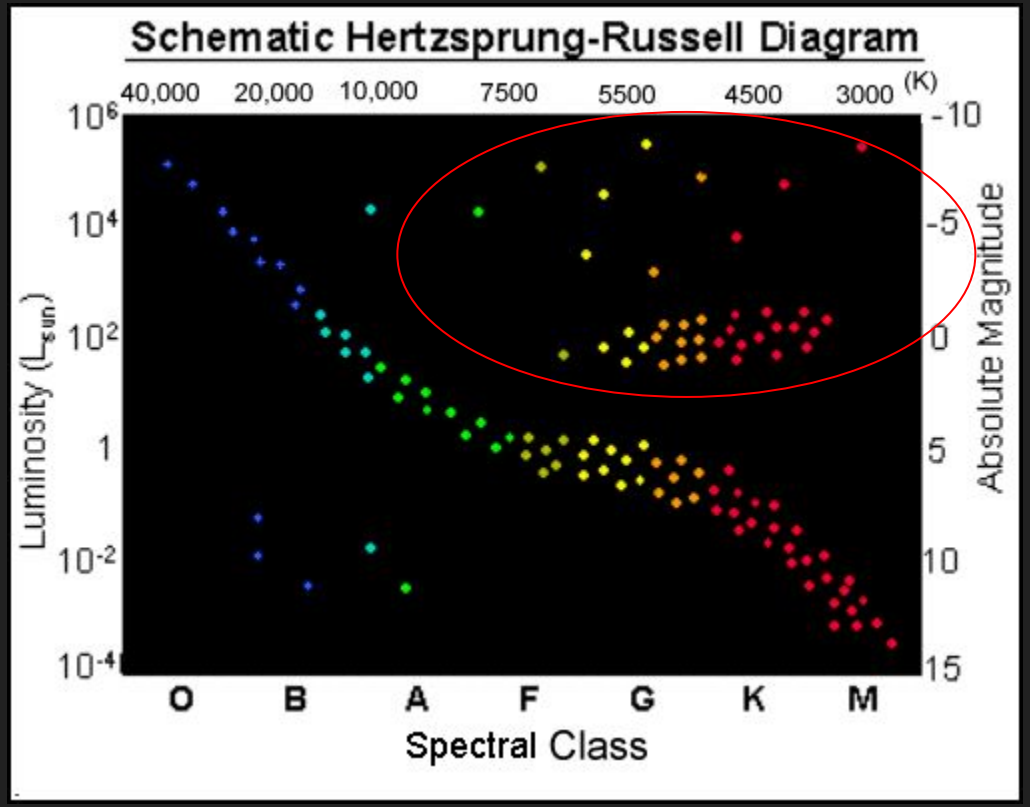


Characteristics of Main-Sequence Stars

Spectral Type	Mass (Sun = 1)	Luminosity (Sun = 1)	Temperature	Radius (Sun = 1)
O5	40	7×10^5	40,000 K	18
B0	16	2.7×10^4	28,000 K	7
A0	3.3	55	10,000 K	2.5
F0	1.7	5	7500 K	1.4
G0	1.1	1.4	6000 K	1.1
K0	0.8	0.35	5000 K	0.8
M0	0.4	0.05	3500 K	0.6

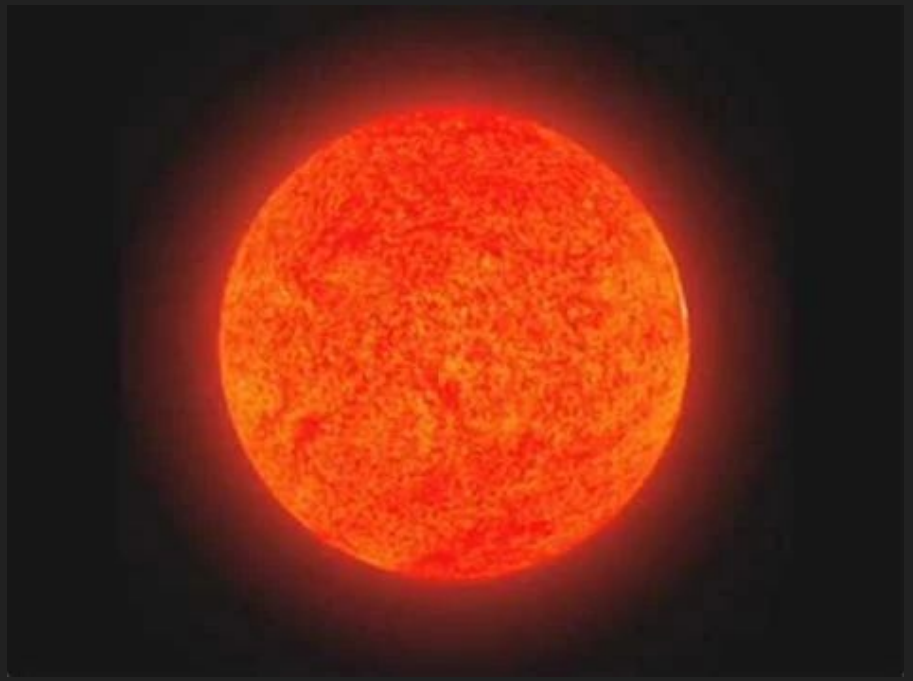
Table 18.3

Supergiants



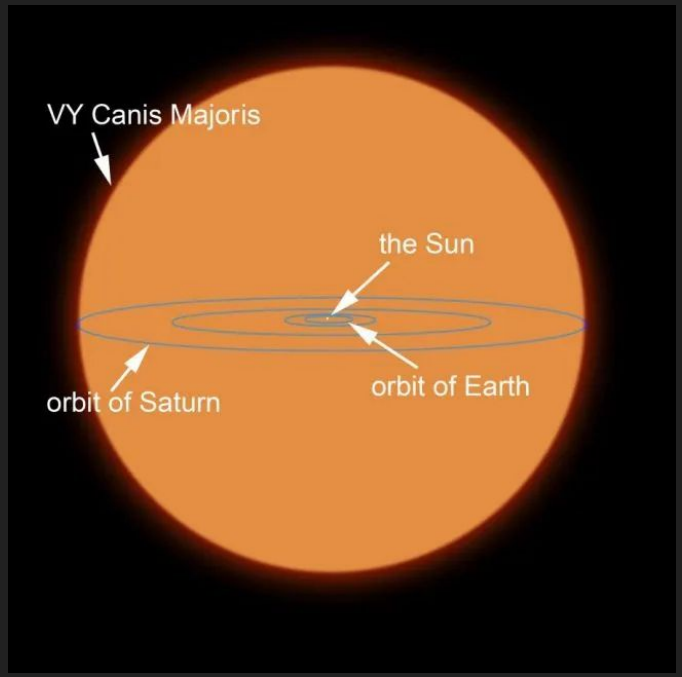
Supergiants

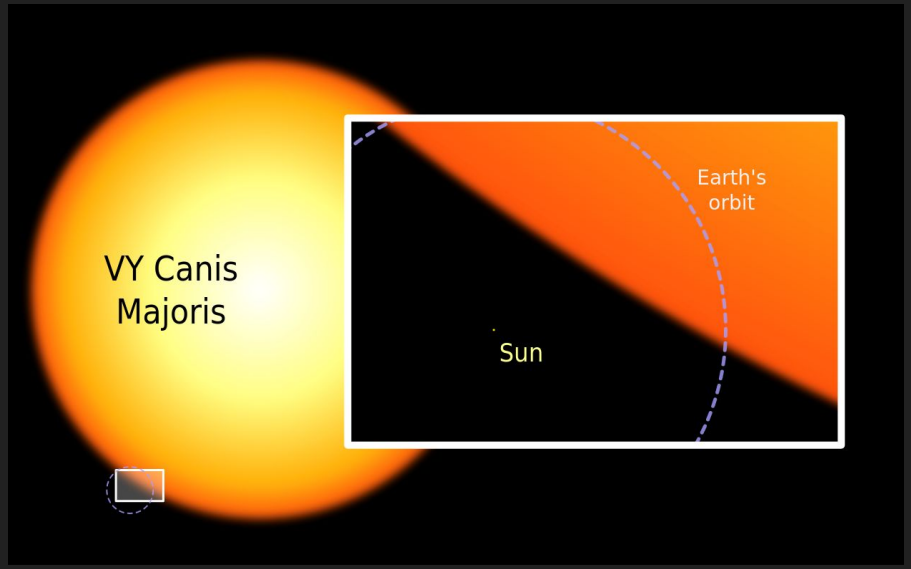
- When hydrogen in the core runs out, the star becomes a supergiant star
- Fusion stops (helium core), core shrinks, helium fuses into carbon…
- Outer layers of star expand from increased pressure from helium fusion, lower temperature



Supergiants

- The star expands significantly during supergiant phase





White dwarfs

- Eventually stars undergo supernova (discussed next class)
- Shed their outer layers leaving behind a dense, hot core
- Call the core remnant a white dwarf

White dwarfs

Announcements

- Homework 6 assigned today

Next time

- Stellar evolution